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J. F. KELLY, *Editor*

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Mr. J. J. Booth, Electrical Superintendent, National Tube Co., Gary, Indiana, President of the Association of Iron & Steel Electrical Engineers for the year 1931-1932.

The President's Message

To the Membership of the Association of Iron and Steel Electrical Engineers

A little over 25 years ago, twenty-eight engineers conceived the idea of the formation of an engineering society, whose aims and objects would be the advancement of the application of electricity to the Iron and Steel Industry. How well they succeeded may be found in the analysis of the following data:

3960 Steel Mill Engineering subjects have been presented before the society to date. These subjects covered practically every phase of the application of electricity in the Iron and Steel Industry. There is no other organization or society that in any way parallels the work of our Association or gives to its members more helpful, constructive engineering data along definite prescribed subjects.

25 year books containing the transactions of the society have been printed and distributed. These year books contain in bound form the transactions of each year and make a ready reference to be placed in any engineering office or member's file. These books may rest undisturbed in the file case for some length of time, until some definite subject arises on which some member desires information, and in many cases, the exact solution or data desired may be found in our own Association Transactions. If however, the exact subject is not covered, all one needs to do is write the home office and they will be only too glad to assist in getting the desired information.

2000 engineers are today interested in the various branches of engineering which the Association has sponsored: Electrical, Combustion, Lubrication and Safety Engineering divisions might be subjects for elaboration, but for our purpose now are self-explanatory.

All of the Association's success and progress has been brought about through the interest that has always been manifested by our membership, and it is our present aim and object to continue to progress and to be of service to the Steel Industry. This service it may be hard to evaluate in dollars and cents. However, as time goes on we believe we can prove to the Steel Mill executives that we do have an economic value and an economic duty to perform. The Steel business of today and its allied industries have to depend in a larger measure than ever before on small profits, with quantity production. Our Association can and must assist in economical applications of electricity, to increase these profits. For after all is said and done, the only reason for business is to produce a reasonable percentage of return on the investment, and this return determines the measure of success of any business. May our Association and its members be more and more instrumental in making the Iron and Steel Business the success it should be.

As the new President of our Association, and on behalf of all of the new executives, which have just taken office, may we solicit your active cooperation for the new year 1931-1932? Your new Board of Directors keenly realizes their responsibilities in keeping the activities and functions of the Association up to the standard set by their worthy predecessors. However, it is also their aspiration and ambition to reach greater heights, which is only possible with the closest form of cooperation of the membership.

Our new committee appointments will appear in the September issue of the Iron and Steel Engineer. Every effort was made in these appointments to select a personnel which would be able to function successfully. Any member who feels he cares to contribute his time to committee work, and who will make his wishes known, will be assigned a responsibility.

Your attendance at Section Meetings is an indication that you are interested in the General Welfare of the Society, and the greatest benefit from your membership in the Association will be derived from your support and interest in its activities. As the executive head of our society, I earnestly urge you to support and encourage your section officers in their program for the next year.

It is appreciated that these are trying times, yet on the other hand, it is a remarkable opportunity for the Association to prepare to be of greatest value when we are back again at the Peak Production Period, for which we are all hoping.

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Air Conditioning and Ventilation†

By W. H. BURR*

The growth of modern industry has made it necessary for the present generation to abandon that once common expression "As pure as the air we breathe."

The question of the pollution of the atmosphere is of such importance that it is being given more careful consideration by Architects and Engineers each year. The smoke nuisance in our large cities was perhaps the first phase of this problem to be given consideration. Rapid strides are being made to improve this condition which is being corrected

W. H. BURR

largely by the electrification of railroads and by dust precipitation.

While electricity is making it possible to eliminate the coal fired Steam Locomotive, it has also been a very important factor in increasing production in most industries. This has resulted in an increased pollution of the atmosphere especially in the modern steel mills.

In the early stages of design of electrical aquipment, forced ventilation was resorted to in the Air Blast Transformer, and later with the advent of Turbo-Generator, fans were provided on the rotor to provide the necessary cooling effect.

The demand for clean air for such purposes led to the development of the Air Washer familiar to most of those present. One of the outstanding advantages of this method of cleaning air was the ease with which the temperature of the air could be controlled. It was, however, more expensive to maintain than some of the more modern air conditioning equipment.

After the Air Washer came the development of what is known as the Viscous Air Filter. The earlier type was made up in small frames. In the frames were copperized rings, expanded metal or steel wool. To clean these, it was necessary to take them out and immerse them in a cleaning solution. This resulted in quite a high maintenance charge.

Then came the Rotary type which was self-cleaning, then the Constant Effect Air Filter, the Horizontal type self-cleaner, and the Streamline Automatic. The basic principle of all these was the impinging of dust particles against some medium which was coated with a viscous solution. These were all described in the 1929 A. I. & S. E. E. Proceedings.

The latest addition to this type filter is the Multipanel Filter which is self-cleaning and is designed for continuous automatic air filtration. A number of closely overlapping screen panels form a continuous moving curtain, the bottom of which is immersed in adhesine filter fluid. The screen panels passing individually through the adhesine bath give up their accumulation of dirt or dust and pass on with a fresh coating of adhesine filter fluid. The adhesine serves as an adhesive and retains the dust and dirt carried by the air passing through the filter. The filter screen is electrically actuated at fixed intervals.

The sludge pans require cleaning at intervals, depending entirely upon the quantity of dirt collected. During dry weather it may be necessary to clean them out every four or five days.

And now we have Dry Process Airmat filters which were developed when experiments showed that there was no available dry filtering material which could meet space requirements and operating characteristics of the viscous type filter.

Airmat is described as an intermediate product in the processing of spruce wood filters to make cellulose the basis of Rayon. Thus, while neither paper nor cloth, it has characteristics of both which makes it an ideal filter. Six of these plies held loosely together by embossing form the mat used in these dry filters. This 6 ply mat is about ⅛" thick, 4 square feet weighs only 1¼ oz.

Whenever the resistance to the air flow reaches an allowable maximum, the sheet is changed or reconditioned by vibrating.

These Airmats are placed in specially designed air pockets about 2' deep, 5" wide at the open end, and tapered to about 2" at the closed end. The air enters the pocket through the opening which is 5" wide and passes out through the Airmat on the two sides. The sheets are supported between the screen panels, the outer one of which is hinged making it easy to renew sheets.

The filter unit, consisting usually of five pockets, is made in the form of a cube, 2'-3" in each dimension.

A single unit is designed to take care of 1750 cu. ft. per minute. The velocity of the air through this mat will be about 45 ft. per minute.

Under general conditions in ventilating systems, a life of about ten weeks can be expected of each

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* Electrical Supt., Lukens Steel Co., Coatesville, Pa.

mat. This, however, depends absolutely on the condition of the air to be filtered.

One of the outstanding uses of this type cleaner is that of a dust arrester which allows the air in the various shops to be recirculated after dust removal, resulting in a considerable saving in fuel required for heating purposes. It is applicable to buffing and fine grinding and to the collection of cotton lint and asbestos fibre.

The vibrators mentioned above on smaller units are hand operated but they are so designed that they can be motor operated and when used in connection with a pressure indicator it is possible to keep within the necessary pressure limits on the Airmat. The maximum resistance should be kept at about 1" water gauge operations. This question of proper ventilation of electrical equipment has now reached the stage where it is necessary to design power houses, sub-stations and motor rooms so that advantage is taken of every local condition which may result in higher efficiencies and lower operating expense.

Very careful consideration must be given to the source from which the air is taken even though it is put through an air filter, for very often the heat from the furnace section and even the mill section may increase the temperature intake air so that it is not suitable for ventilation purposes.

Care should also be exercised in locating this intake to make sure that no smoke from locomotives or acid fumes will be drawn into the ventilating system.

In the design of all modern electrical equipment very careful consideration is being given to proper ventilation, even housings and covers are being so designed that the air travels in a definite path and no recirculation takes place.

Modern efficiency makes it imperative that no loss due to ineffective windage be tolerated and that only that amount of power which is absolutely necessary be spent for ventilating purpose.

Where it is not possible to obtain good cool air for ventilation purposes, a closed system with continuous recirculation, the air cooling being effected by water cooled air coolers, offers a very satisfactory solution to this problem. When this method can be used, the size of the ventilating fan and air conditioning equipment can be greatly reduced. This system may be used to advantage on individual motor drives and also in motor rooms when both the MG sets and main drive motors are located.

Realizing the benefits which have been derived from the proper conditioning of air in large motor installations, all manufacturers of small motors have now developed fan cooled motors.

As a result, these motors are operating with lower maintenance cost and when compared with the old totally enclosed motors show a very marked reduction in material used and consequently in first cost.

In my opinion, it will not be long until this fan cooled motor will replace to a large extent the open type general purpose motor of today.

Air conditioning equipment has so revolutionized modern practices that I believe the time will come when the air in our homes and our places of employment will be so regulated that it will be considered just as essential to have the temperature maintained at a certain fixed degree in the summer as we do now in the winter season.

Series Lighting in the Steel Plant†

By E. ANDERSON*

Due to the ever increasing size and safety requirements of the modern steel plant the problem of efficiently illuminating the yard areas and thoroughfares throughout the plant is one which requires considerable thought and study.

In laying out such a lighting system two methods present themselves. The multiple and the series system: this latter system being the one we wish to discuss.

Much has been written covering the installation and operation of the series system by the various manufacturer's of street lighting equipment, and it is therefore the object of the writer not to enter into a detailed description of the equipment involved, but to give a brief resumé of its adaptation to steel plant yards.

This system is particularly advantageous to a plant where a large number of departments are widely separated. The series system is chosen over its equivalent multiple system for three reasons: First —Lower installation cost, Second—Better efficiency, both from a standpoint of lighting and power consumption and Third—Lower Maintenance.

The lower first cost of the series system is accounted for by the difference in conductor size required and the size of the structures necessary to support same. Two #6 weatherproof wires will serve a series system of virtually unlimited size, whereas for an equivalent multiple system conductors of larger cross section are necessary to prevent excessive voltage drop, and even with such conductors the size of the system is limited.

More efficient operation is obtained from a lighting standpoint because with the series or constant current system each lamp delivers its rated lumen output regardless of the length of the circuit or its distance from the transformer. With the equivalent multiple system the lumen output from the lamp varies approximately as the cube of the voltage applied at the lamp terminals, i.e., with 95% voltage approximately 85½% lumen output will be obtained. It may be readily seen that a multiple system with low line drop requires the installation of larger copper conductors than those required for the series circuit. Lower line losses on the series system are

† Presented before Philadelphia Section, A. I. & S. E. E., April, 1931.

* Electrical Department, Bethlehem Steel Company, Sparrows Point, Md.

accounted for by the smaller value of current to be handled.

The greater efficiency in lumen output of the series system is a characteristic of the series lamp. In tungsten filament lamps the filament vaporizes and condenses on the inside of the bulb forming a dark coating over the surface which reduces the lumen output as the life of the lamp increases. This vaporization of the filament reduces its cross section thereby increasing its resistance.

In the series lamp this increase in filament resistance causes an increase of filament temperature resulting in an increase in lumen output sufficient to offset the effect of the coating on the inside of the bulb. Therefore this type lamp will produce an almost constant lumen output over its entire life.

With the multiple lamp the increase in filament resistance causes a decrease in filament temperature as the life of the lamp increases resulting in a reduction of the lumens generated. The per cent decrease varies with the size of the lamp but a 100 watt 115 volt lamp will show a reduction of approximately 15% at the end of 1000 hours.

The heavy, rugged filament in the series lamp resists the effect of vibration much better than the filament in the multiple type of lamp, therefore lamp renewals are less frequent and consequently the maintenance of the system lower.

The following tabulation shows the comparative cost and data on a series and a multiple system each of the same lumen capacity.

The series system is typical of a steel plant yard installation and consists of a 28 KW regulator feeding 182-2500 lumen lamps on a circuit made up of 54,600 feet #6 WP wire.

The multiple system has been laid out to include 6-5 KVA transformers connected to the plant high voltage system and located so as to feed into the low voltage circuit at the most economical point. The secondaries have been kept isolated from each other so that each transformer carries its individual portion of the lighting system. These transformers will serve 197-150 watt lamps connected to a circuit consisting of 53,200 feet #2 WP wire. The #6 wire listed in the tabulation constitutes the high voltage circuit for the transformer primaries.

ITEM	SERIES	MULTIPLE
Total lumen capacity	455,000	455,000
No. lamps	182	197
Size of lamps	2500 lumen-147.18 watts	150 watt-2310 lumen
Cost of lamps	$180.00	$80.00
Cost of fixtures	$2110.00	$2090.00
Spacing of fixtures	150 ft.	139 ft.
Cost of supports including foundations	$10,000.00	$13,000.00
Insulators	$320.00	$600.00
Size of conductor	#6 WP	#6 WP #2 WP
Feet of conductor	54,600	46,000 53,200
Cost of conductor	$755.00	$2,470.00
Transformer capacity	28 KW-25 cycle	6-5KVA-25 cycle
Cost of trans. capacity	$650.00	$560.00 inc. cutouts
Installation and misc.	$1,785.00	$3,000.00
Total cost	$15,800.00	$21,800.00
Losses per hour inc. transformer	2,080 watts	2,632 watts
Voltage of system	Approx. 4,250	120 AC-25 cycle
Voltage drop % and value	Does not effect lumen output of lamp	6.4%-7.7 volts
% Lumen output at farthest lamp	100%	82%
% Lumen output average of all lamps	100%	91%
Total effective lumens	455,000	415,000
Installation cost per effective lumen	3.48c	5.25c
Power consumption. Cost per lumen year based on 96% Eff. of Series Trans. 97% for multiple system trans. Power at 1c per KWH. 3600 hrs. per year	.231c	.268c

Regulators or constant current transformers can be purchased as a rule for operation on any standard frequency or voltage up to and including 13,200 volts. It is therefore generally the most economical practice to have these units arranged for operation on the station low voltage AC system. A small solenoid operated oil circuit breaker and motor driven time switch is all that is necessary to make the system entirely automatic. The only meters necessary are an indicating ammeter with 10 ampere scale connected with a suitable current transformer in the regulator secondary circuit and an integrating watt-hour meter connected in the regulator primary. The secondary current in the system should be kept at 6.6 amperes by adjusting the counterweight on the regulator; once set no change should be necessary unless the number or size of lamps in the circuit is changed.

Lamps for use on a current of 6.6 amperes are made in sizes ranging from 600 lumens to 6000 lumens. The 2500 lumen lamp has been found well suited for yard lighting and at a mounting height of 17 feet from the yard level will produce with fixtures on approximate 150 ft. centers .5 foot candle intensity directly under the fixture, .02 foot candle intensity at center between two fixtures or an average intensity of .26 foot candles. These values are well within the limits recommended for this type of lighting.

Fixtures in general are of the pole mounting bracket type with film cutouts. Ornamental standards may be used to advantage to harmonize with the surroundings of Main Office buildings, central dispensaries, etc. This latter type of fixture is preferably equipped with a suitable current transformer located in the base of the unit. The transformer primary is connected in series with the 6.6 ampere circuit and the secondary of the transformer is connected to the lamp. This arrangement eliminates the high voltage of the primary circuit on the lamps and prevents the standard becoming "Alive" should any part of the wiring ground. It also eliminates the film cutout as the secondary circuit of such a transformer may be opened without any danger to persons or equipment.

Fixtures and wiring may be mounted on existing tower lines, buildings etc. or in cases where such supports do not exist a 22 ft. length of 6" standard pipe set in a concrete foundation and equipped with a suitable support for the insulators and fixture bracket will provide a cheap and effective, as well as a fairly good looking installation. Open wiring con-

sisting of #6 B & S gauge stranded copper conductors with weatherproof insulation mounted on white insulators suitable to withstand the maximum open circuit voltage of the regulator is the cheapest and general installation. In cases where lines cross railroad tracks or it is desirable to conceal them, Parkway cable may be laid underground and brought up through the foundation and support to the fixtures.

In closing I wish to state that in my opinion the series system due to its lower cost, greater efficiency and flexibility, is well adapted to steel plant yard lighting installations.

Principles and Some Practical Applications of Electric Furnaces with Atmospheric Control†

By A. N. OTIS*

The subject of atmospheric control of electric furnaces has recently become prominent, due to the fact that new methods have been devised for producing gases suitable for furnace atmospheres, from readily available materials and at low cost. This development opens a field of vast possibilities for the use of electric furnaces, as well as for substantial improvement in annealing processes, and with indicated savings in cost.

Electric furnaces with hydrogen atmospheres have been used for some years, for certain processes, such as annealing steel sheet and laminations for generators, transformers and motors, the original furnaces having been made economical by the then existence of a surplus of hydrogens, for which no use could be found.

Later, hydrogen furnaces came into quite extensive use for the copper brazing process. By means of this process a number of parts can be united into a complicated assembly at one operation, the joints being mechanically strong, liquid and gas-tight, and presenting a smooth and neat appearance. This development has been of very great importance in certain lines of manufacture.

This experience with furnaces using hydrogen as atmosphere has served to develop the principles of operation, and the technique for handling the gases, from the standpoint of the requirements for safety, etc.

One of the handicaps to a wider use of furnaces with these atmospheres has been the cost of hydrogen. This gas can be procured in pressure tanks from companies which manufacture oxygen by the electrolytic method, i.e. the electrolysis of water, hydrogen being a by-product from such manufacture.

If a user has a considerable demand for oxygen, to be used for cutting or similar operations, conditions may justify the installation of an electrolytic plant to produce it. This makes a supply of hydrogen also available.

Even by this method, the cost of hydrogen is comparatively high, and the generating plant requires a considerable investment, so that conditions have operated to retard the development and use of furnaces which would require hydrogen in considerable volume, even though their advantages had been demonstrated.

These conditions have stimulated a study of methods to produce gases rich in hydrogen, with the possibility of reducing the cost of such gases and simplifying the processes for producing them. The study has resulted in the development of apparatus for re-forming hydrocarbon gases, such as butane, illuminating gas or natural gas into a gas consisting largely of free hydrogen, and also apparatus for dissociating ammonia into hydrogen and nitrogen, its component elements.

The apparatus is simple, compact and inexpensive, and produces gases entirely satisfactory for use as furnace atmospheres.

Such gas equipment will make possible the use of electric furnaces in steel plants for annealing sheets, coiled strip, bars, tin plate, etc., without the use of boxes or covers, and with equipment requiring less floor space than that at present in general use.

In order to secure a clear understanding of the importance of this development, it may be of interest to review briefly the methods and apparatus used for producing these gases, and compare the cost of gases by the various methods of procurement.

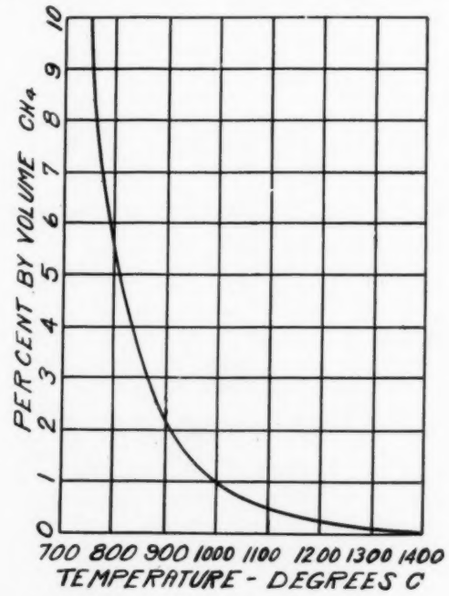

Fig. 1.—Equilibrium relation of hydrogen-carbon-methane with temperature, in the dissociation of hydrocarbon gases.

As previously stated, hydrogen may be procured in pressure tanks, or it may be produced by the user,

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* Industrial Engineering Department, General Electric Company, Schenectady, N. Y.

in an electrolytic cell plant as a by-product from the manufacture of oxygen.

The apparatus for producing it by dissociating hydrocarbon gases, such as butane, illuminating gas or natural gas, consists of an electric furnace with a multi-tubular retort, through which the hydrocarbon gas, mixed with steam, is passed.

Coke oven gas may be taken as typical of available gases. This gas consists of approximately 55% of free hydrogen, 28% methane (CH_4), together with small percentages of other hydrocarbons and nitrogen.

Methane may be dissociated into carbon and hydrogen by heat alone, there being a definite equilibrium curve with temperature, which constitutes the law of dissociation. This curve is shown in Figure 1, and it will be noted that as the temperature increases, the percentage of methane which can remain, rapidly decreases, being dissociated into hydrogen and carbon, so that for example, at 1000°C., only 1% of methane can be present If the temperature is carried sufficiently high, complete dissociation occurs as indicated.

If steam be added with the hydro-carbon gas, it also dissociates into hydrogen and oxygen. The oxygen combines with the carbon released from the methane (CH_4) while in the gaseous state, to form carbon monoxide, (CO). Hydrogen, therefore, is obtained from three sources: (1) the free hydrogen of the original gas, (2) that released from the dissociation of CH_4, and (3) that released from the dissociation of steam, (H_2O), so that the resulting gas consists of approximately 75% hydrogen, 20% CO, 1% methane and 4% nitrogen, which is inert, and comes through from the original gas. The volume of product gas is double the volume of coke oven gas used, and with natural gas it is four times the original volume.

The name "Electrolene" has been given to this product, and while not a pure gas, it is entirely suitable for use as furnace atmospheres.

An electrolene producer of 600 cu. ft. per hour capacity is shown in Figure 2. It is built in several sizes, and is an extremely simple apparatus and simple to operate. The only elements necessary to produce the gas are: a hydro-carbon gas, electric heat, and steam. The control is entirely automatic.

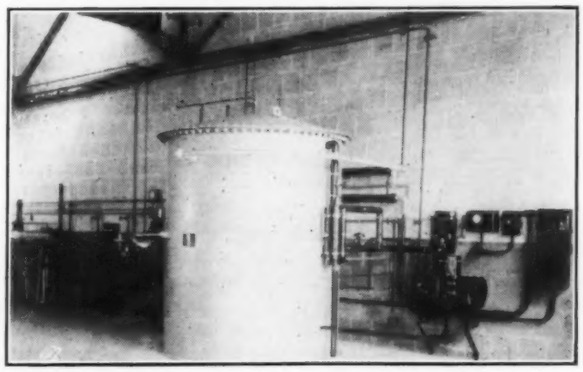


Fig. 2.—Electrolene producer, capacity 600 cu. ft. per hour.

Anhydrous ammonia (NH_3) may also be dissociated by heat into its component gases, hydrogen and nitrogen, the resulting gas being composed of 75% hydrogen by volume and 25% nitrogen. The anhydrous ammonia may be purchased in pressure tanks in liquid form, which tanks may be connected to the producer by a suitable reducing valve. Figure 3 shows a small apparatus for this purpose. It has capacity of 50 cu. ft. per hour, and was developed primarily for use with atomic hydrogen welding sets.

The cost of gas by these several methods of procurement is indicated in the following table:

Cost of Gas by Various Methods of Procurement

Source	Cost Per M. cu. ft	% Hydrogen Present	% Reducing Gas Present
Purchased in Pressure Tanks	$10.00	99.0	99.0
Dissociated Ammonia	4.00	75.0	75.0
Electrolytic Process	2.50	99.0	99.0
Electrolene	.45 to .65	75.0	95.0

The cost of electrolene will vary with the kind and cost of hydrocarbon gas available.

These costs are approximate. They indicate, however, the general and relative costs, and emphasize the importance of the development of Electrolene, as a low cost gas for furnace atmospheres.

The materials from which this gas is made, and the simplicity of the producer, make it available everywhere for use in furnaces with controllable atmospheres.

In order to have a clearer understanding of the function of a furnace atmosphere, it may be well to review briefly the reactions which take place in the oxidation of metals or the reduction of metallic oxides. The practical effects of oxidation, and the reduction of oxides are well known, but the reactions of the process are not as well understood.

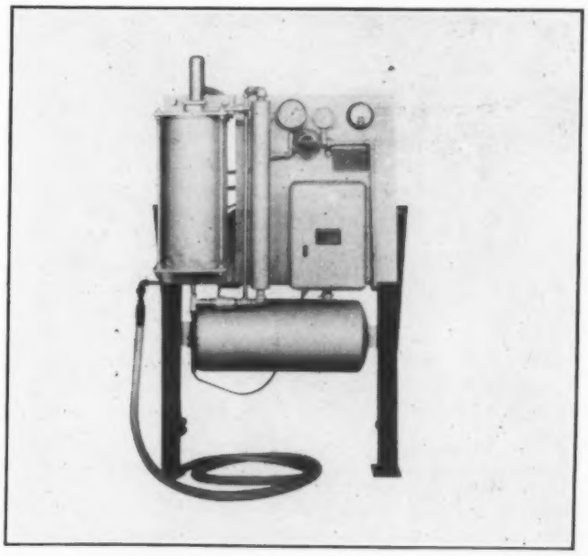


Fig. 3.—Ammonia dissociator with regulating apparatus and storage tank. Capacity 50 cu. ft. per hour.

Metallic oxides may be dissociated by heat, i.e., the oxygen may be driven off in a manner somewhat analogous to the vaporization of water by heat. At elevated temperatures, partial pressures of oxygen are exerted, which tend to free the oxygen from combination, the action depending upon the temperature and external oxygen pressure.

This may be well illustrated by an experiment to show the dissociation of mercuric oxide into mercury and oxygen, and the reverse process of forming mercuric oxide from mercury and oxygen, by means of

varying the temperature and pressure. The experiment may be conducted as follows:

If mercuric oxide be heated to the proper temperature, in a closed chamber to which an exhaust pump is connected, it will be dissociated into mercury and oxygen, the oxygen being removed by the pump as fast as it is driven off. If now the pump be stopped, the dissociation will cease when an oxygen pressure of 1.6 atmospheres has been built up, assuming a constant temperature of 1112°F. to be maintained. At such pressure and temperature, the system mercuric oxide-mercury-oxygen is at chemical equilibrium.

If the oxygen pressure be now lowered below 1.6 atmospheres by starting the pump, the dissociation will be resumed, and if the oxygen pressure be raised above 1.6 atmospheres by some means, the action will be reversed, the oxygen combining with the metallic mercury to form mercuric oxide.

It is thus possible to have oxidizing, neutral or reducing conditions in this experiment by **varying the pressure of oxygen only.** This experiment, while simple in itself, explains the fundamental processes of the oxidation of metals and the reduction of metallic oxides, and shows that the actions depend on the temperature and the partial pressure of oxygen in the atmosphere.

To apply these principles to a furnace atmosphere, it is necessary to provide means to reduce the oxygen pressure to a low value, or to replace the pump used in the experiment. This is readily accomplished by the use of an easily oxidizable gas such as hydrogen or carbon monoxide.

Above red heat, hydrogen will combine with any free oxygen present or procurable with great rapidity, consuming it as fast as it is formed, which thus tends to lower the oxygen pressure in the atmosphere of the furnace to a low value, and is comparable to the action of the pump referred to in the experiment. As the partial pressure of oxygen is thus lowered, more oxygen will be driven off from oxides if present, and will continue to be driven off as long as any remains, provided that the hydrogen content of the atmosphere is maintained above the equilibrium value, or of such proportion as to consume the oxygen.

It is thus apparent that the formation or reduction of a metallic oxide, is dependent upon temperature and the partial pressure of oxygen in the atmosphere surrounding the obejct. If the oxygen pressure is high at a given temperature, it will tend to form oxide, and if the oxygen pressure is low at a given temperature, it will tend to reduce the oxide, or conversely, to prevent its formation, the principle function from a practical viewpoint.

It is theoretically possible to reduce the oxides of all metals by controlling the partial pressure of oxygen by means of vacuua or compression. In general, however, the vacuua would have to be exceedingly high, as illustrated by the following table, which shows the dissociation pressure in atmospheres for iron oxide, at various temperatures.

Dissociation Pressure in Atmospheres For Iron Oxide, FeO.

Temperature Deg. Cent.	Pressures in Atmospheres
32?	5.1×10^{-42}
52?	9.1×10^{-30}
72?	2.0×10^{-22}
92?	1.6×10^{-19}
112?	5.9×10^{-14}
132?	2.8×10^{-11}

It is a striking fact that the presence of a strongly reducing gas such as hydrogen, lowers the partial pressure of oxygen by rapid combination with it, to exceedingly low values, and is in fact a pump of extraordinary capacity.

Let us imagine an electric furnace, containing and surrounded by air, consisting of 80 parts nitrogen and 20 parts oxygen at a pressure of 14.7 pounds per square inch. The partial pressure of oxygen in this case, represented by normal air at normal pressure, is enormous when compared to the exceedingly low value represented by the dissociation pressure of most oxides.

Atmospheres of pure hydrogen, however, are not necessary, the effect of other gases such as nitrogen being to dilute the atmosphere, but having no fundamental effect on the action as long as the hydrogen content is kept above the equilibrium value, i.e. the value at which the necessary reaction will take place.

Furnace atmospheres in practice may consist of hydrogen, mixtures of hydrogen and nitrogen, electrolene, and for certain low temperature operations, raw illuminating gas may be used. This gas, however, is likely to dissociate and leave a carbon deposit in the furnace according to the dissociation curve shown in Figure 1. It is often necessary to purify these gases for traces of oxygen, water vapor or sulphur which they may contain, particularly if bright annealing is desired.

Furnace operations in this connection may be divided into certain classes, such as strictly bright annealing, so-called clean annealing, in which stains or browning is not objectionable as long as no oxide or scale is formed, and third, cases where slight oxidation is permissible. The surface condition will also be effected by the cooling arrangement, which should also be designed for the purpose at hand.

For bright annealing, it is necessary to use considerable care to purify the gases of oxygen, water vapor and sulphur, and also to see that the surfaces are clean before the material is loaded into the furnaces. Such an application is the bright annealing of cold rolled steel strip, generally supplied to the market in coiled form.

In the second class would fall such materials as sheets for tin plate or for galvanizing, which require pickling before the final operation, and in which slight darkening of the edges is not objectionable, as it is readily removed by the pickle.

In the third class might be included materials such as sheets for furniture or automobiles, in which the edges are usually trimmed and a discoloration therefore is not objectionable, or silicon sheets for electrical machinery from which strips and punchings are made; also wire in coils, to be annealed between drawing operations, in which a slight oxidation is permissible.

In the first of these operations, requiring a strictly bright finish, it is necessary that the heating and

cooling be done under a tight hood or cover and that the gas be purified. Furthermore, it is necessary that the material cool nearly to room temperature before exposure to the air. The nature of the requirements will determine the extent of purification and the care necessary for the desired results.

The purifier may be a comparatively simple apparatus, consisting of a set of tubes or containers for chemicals such as iron oxide, copper chips, calcium chloride, and potassium hydroxide, through which the gases are passed for purification. The copper chips should preferably be heated to increase their activity toward oxygen.

As this strip comes from the rolls, it is generally coated with a film of lubricating oil, which will be vaporized and gradually driven off as the material is heated. When all these vapors have been exhausted, illuminating gas or other suitable gas may be passed through the hood, for a time to clear the atmosphere, and then the exhaust valve closed, a slight positive pressure being maintained in order to exclude air.

It is generally unnecessary to circulate gas continuously, particularly if the hoods are provided with liquid seals. The liquid seals serve to exclude air more effectively than sand or similar seals, as such seals are porous and allow the escape of gas. This in turn would require a continuous supply or flow, and a continuous flow would carry in more impurities in the form of moisture or oxygen into the retort.

It is therefore preferable to close the exhaust valves when the atmosphere has been cleared of smoke and other products of volatilization, and maintain a slight positive pressure of gas which is held by the liquid seals.

During cooling, the gas will tend to contract, and will suck air in through the seals if allowed to do so, and the slight positive pressure maintained also compensates for this contraction.

Fig. 4.—Hood type furnace for bright-annealing cold rolled strip in coils.

Figure 4 shows a type of furnace well suited for annealing this material. It consists of several bases, mounted on wheels and arranged to run on a track, the coils of strip being stacked on one another and covered by an annular shaped hood of thin heat resisting alloy. The bottom of the hood is provided with a ring seal to engage with a channel containing liquid around the base.

The furnace proper consists of a bell-type cylindrical chamber arranged to fit down over the retort, and having a central heater which extends downward into the middle of the stack. This central heater applies heat to the inside of the coils, which shortens the heating time as compared with a furnace having units on the outside of the stack only.

These furnaces are designed to take loads of 2½ to 3 tons of coiled strip, which can be heated to annealing temperature, (approximately 1350°F.), in 7 to 9 hours, depending upon the weight of the charge and the thinness of the strip, thin strip requiring a longer time due to the larger number of laminations.

About three charges per day can therefore be produced, giving an output of approximately 7½ tons per day. About 30 to 36 hours are required to cool the material from the annealing temperature to the uncovering temperature, (about 175°F.), so that five bases are required for each heating chamber, four charges cooling while one is heating. Sometimes six bases can be used to advantage.

Due to the small inside diameter of the coils, it is desirable to move the heating chamber up and down in a straight vertical path, and this requires vertical guides for the furnace. These vertical guides may be conveniently incorporated into a tower structure, which also may be used to support a hoist for lifting the heating chamber. Furthermore, a number of these furnaces may be assembled into a group with a tower structure spanning the group, and a traveling hoist arranged to run along the tower structure and be spotted over any one of the furnaces which it may be desired to raise. Such an arrangement is shown in outline on Figure 5, which indicates the layout for two groups of six furnaces per group, a tower structure with a traveling hoist spanning each of the groups.

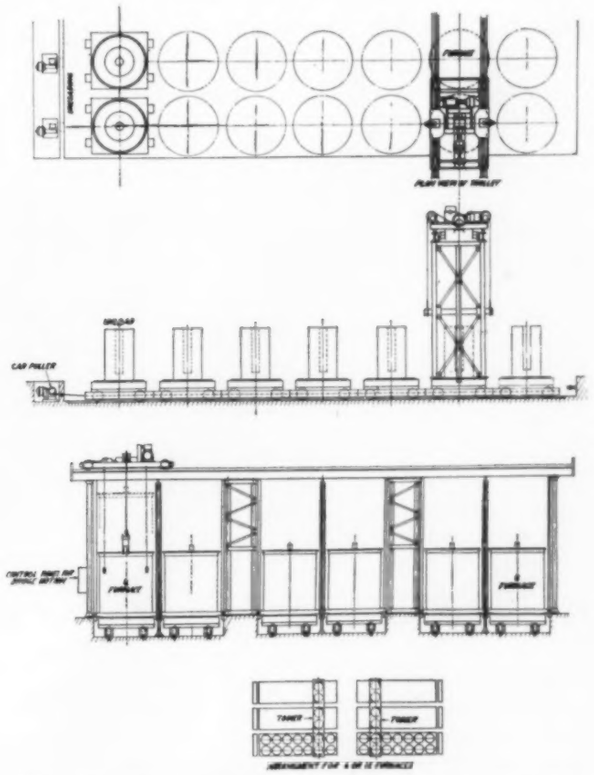


Fig. 5.—Arrangement of plant with hood furnaces for bright-annealing cold rolled steel strip in coils.

In operating the furnaces, the heating chamber would be raised by the traveling hoist, and a rope from the car puller would be attached to the rear end of the entering car. When pull is applied to the rope, the entire train will be advanced, the hot car being pulled out from under the heating chamber and the cold car pulled in. The successive cars beyond the heating chamber would be cooling, and would be at successively lower temperatures, the last one being ready to unload. After unloading, the car with its cover hood would be lifted by shop crane and carried to the entrance end of the furnace, where it would be set down on the track and loaded with a new load of material.

The heat required for this annealing process is approximately 175 KWH per ton, depending somewhat upon the time cycle and the thickness of strip. The time of heating is considerably shorter than that required in fuel-fired furnaces using heavy bases and covers, and the labor also is considerably less, indicating a saving of about $2.00 per ton as compared with the usual methods of annealing.

Several installations of these furnaces are in operation and others under construction. It appears that this type of furnace is likely to come into general use for annealing coiled strip, due to the economies which it makes possible, and the high quality of work produced, both as to uniformity of hardness and excellent surface finish.

Figure 6 shows in outline a fuel furnace of the type in general use for annealing. The sketch shows it as applied to coiled strip, and the same type of equipment is used for annealing sheets, tin plate and similar products, as is well known.

DOUBLE END BOX ANNEALING FURNACE

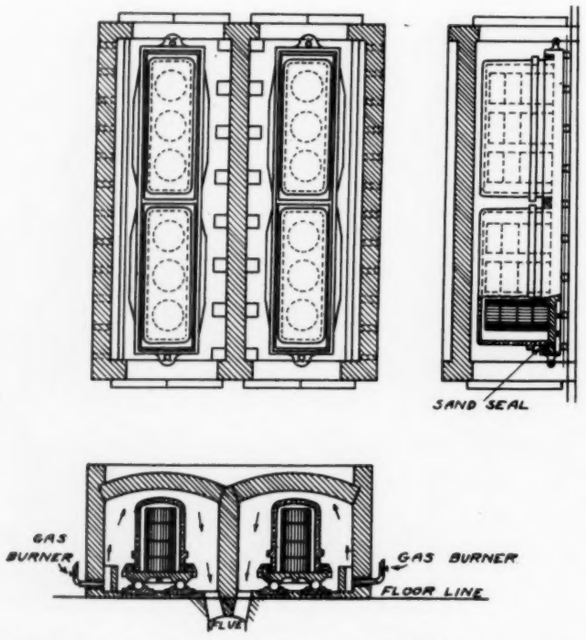


Fig. 6.—Usual type of fuel fired annealing furnace, employing heavy bases and covers for the stock.

The material is loaded on heavy bases of cast steel, and covered by heavy covers, usually of the same material, the weight of base and cover often being more than the load itself, and sometimes twice the weight. The bases and boxes warp and deteriorate due to repeated heating, and a considerable amount of time and floor space is required for the mass to cool after removal from the furnace. Also considerable labor is required for handling the heavy boxes and covers.

The temperature distribution is not uniform, and often material is under-annealed at the bottom and over-annealed at the top, due to the great weight of the base which must be raised to temperature before the stock can reach temperature. Approximately twice the time is required for heating and cooling as is required with the electric furnace described, due to the much smaller masses to be heated in the latter, and more favorable distribution of heaters with relation to the charge.

In the electric furnace, the heat distribution is fixed and invariable, and when once properly proportioned will so remain. This, combined with automatic temperature control, which limits the maximum temperature, makes possible rapid and uniform annealing, and the liquid seals preclude the possibility of air reaching the chamber to discolor the work.

For annealing sheets, several methods may be employed, depending on the surface conditions required. The simplest case is the elevator type furnace which has been in use for some years for annealing silicon sheets in an atmosphere of hydrogen.

Furnaces using hydrogen for atmosphere require that the opening be on the under side, because the gas is light, and if opened at the top or the end, a considerable amount of the gas would be lost each time the furnace was opened, and furthermore, air would enter the furnace, which it is generally desirable to avoid. With the opening on the underside, however, very little loss of gas is encountered. Such a furnace is shown in Figure 7.

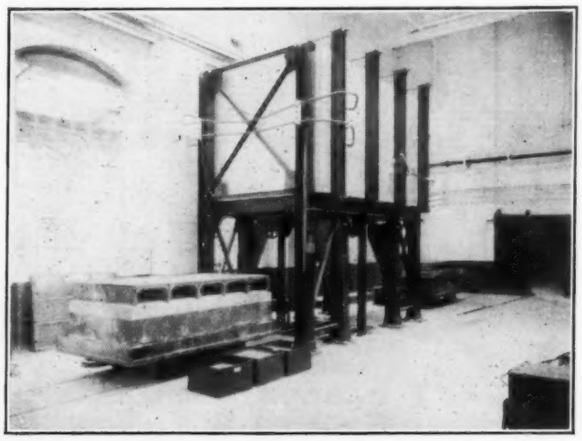


Fig. 7.—Elevator type furnaces for annealing sheets in atmosphere of hydrogen.

The material is loaded on cars to a height of, say 3 feet, and the loaded car run under the furnace to an elevator platform by means of which it is raised into position, a seal around the car engaging with a blade around the bottom of the chamber.

Loads of 16 to 20 tons of sheet are handled at a time. Approximately 24 hours being required to heat and soak a load, the car then being lowered from the heating chamber and pushed out on the track, a steel plate hood being placed over the load,

the hood also containing gas. This method of operation exposes the hot sheets to the air during the time of transfer, and may cause some etching of the edges, which may or may not be objectionable, depending upon the purposes for which the sheets are to be used. Sheets so annealed are perfectly clean except for these edge stains, and are in marked contrast to sheets annealed in the usual furnace.

For some materials, it is not permissible to expose them to the air during the act of transfer. An example is sheet for tin plate, the edges of which will not tin properly if they have been exposed to the air at high temperature.

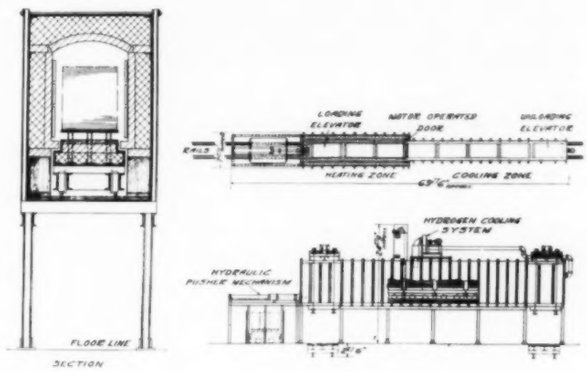


Fig. 8.—Outline of tunnel type furnace for heating and cooling in atmosphere of electrolene.

To meet such requirements, a furnace of the tunnel type, in which the work is cooled to low temperature before discharge, would be well adapted. Such a furnace is shown in outline in Figure 8. This is in fact an elevator furnace, elongated and provided with a cooling hood continuous with the heating chamber. The work would be loaded on cars, the cars being pushed through the furnace on a track of standard rails, to another elevator at the discharge end, by means of which they may be removed.

The furnace shown would have capacity to anneal approximately 50 tons of sheet per day in continuous operation, the work being heated to 1350°F. and cooled to 350°F. before discharge. Annealing at 1350°F., the heat required would be about 160 KWH per ton and electrolene required, 125 cu. ft. per ton.

Such furnaces may also be used to anneal coiled strip, wire and similar products as well as sheets, but strictly bright annealing cannot be expected in furnaces of this type, since small quantities of water vapor are formed each time the furnace is opened, due to the burning of hydrogen in contact with the oxygen of the air. These small quantities of water vapor will darken the outer surfaces slightly, and will not produce a strictly bright surface, but for annealing between rolling or drawing operations, such surface would generally be satisfactory, as it is also for most sheet products.

For operations on a still larger scale, a counterflow type furnace could be built. This is, in fact, two tunnel type furnaces side by side, with two rows of work traveling in opposite directions. Such a furnace is shown in outline in Figure 9. The heating chamber is approximately at the middle of the furnace with recuperative chambers at each end of the heating chamber, and cooling chambers consisting of steel plate only extending beyond, in which the material would be cooled to discharge temperature. These furnaces can be designed for an output of 100 tons per day or more, and due to the recuperative feature, a considerable saving in heat is possible. At 1350°F. the requirements would be approximately 130 KWH per ton, and electrolene consumption about 125 cu. ft. per ton.

These types of furnaces require much less floor space for equivalent capacity than fuel-fired equipments, the latter requiring large storage space for the boxes while cooling, and due to the mass, cooling is slow.

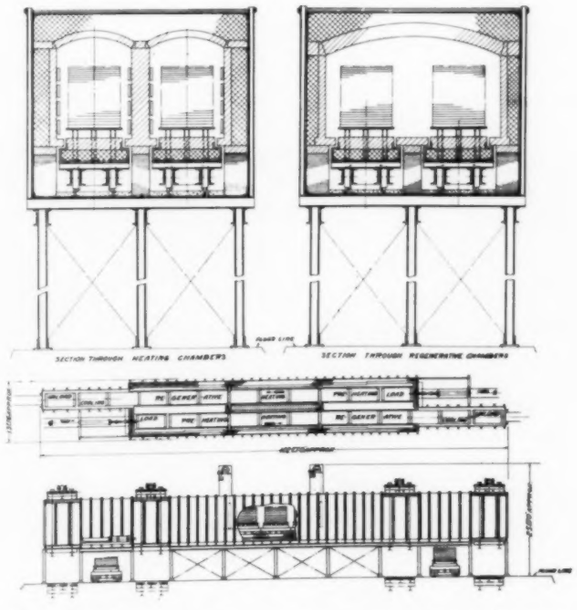


Fig. 9.—Outline of tunnel type counterflow furnace for heating and cooling in atmosphere of electrolene.

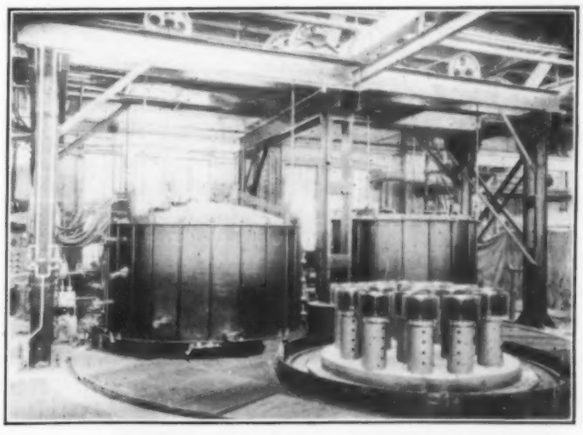


Fig. 10.—Hood type furnace for copper brazing in atmosphere of hydrogen.

The development of electrolene as a low-cost source of hydrogen, has made possible the use of electric furnaces for the purposes outlined, and opens up a broad field for the modernization of annealing equipment, which has had comparatively little attention from steel mill engineers, even though rapid progress has been made in other lines.

Fig. 11.—Group of elevator furnaces for annealing electrical sheets in atmosphere of hydrogen.

An early form of the hood type furnace is shown in Figure 10. This consists of a heating chamber and a cooling chamber in the form of separate hoods, both containing hydrogen. When it is desired to shift the loads, both hoods are raised by the steel ropes shown, and the floor plate rotated one-third

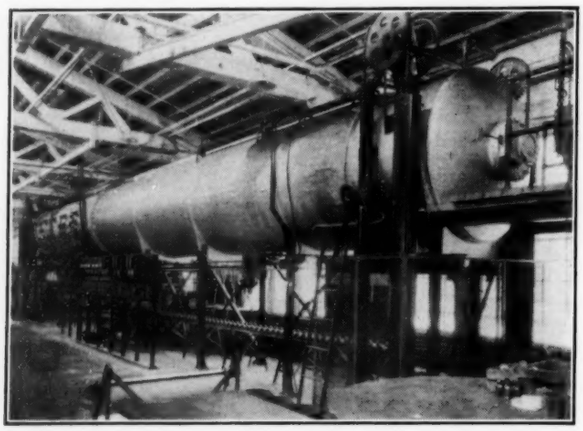


Fig. 12.—Tunnel type furnace for copper brazing, having cooling chamber continuous with the heating chamber.

revolution, which transfers the hot charge to the cooling chamber, the cooled charge out into the open where it can be unloaded, and puts a new charge into the heating chamber. Such furnaces have been used for brazing for some years.

A group of the elevator type furnaces is shown in Figure 11. These are used for annealing silicon sheets and strips for transformers, motors and generators. There are ten of these furnaces installed in this plant, four of which are shown. These also have been in use for some years.

Figure 12 shows a continuous type furnace consisting of a heating chamber at one end and a water-jacketed cooling chamber continuous with it, the work being pushed through to the discharge end, where it is removed at a comparatively low temperature. There are five of these furnaces in use for copper brazing, the furnaces being some 60 ft. long and operating at a temperature over 2000°F.

The straight-flow and counter-flow furnaces previously referred to for annealing sheets or coiled strip

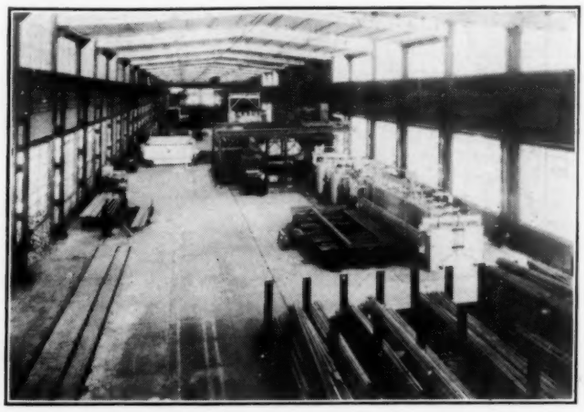


Fig. 13.—General view of heat treating plant for bar stock, 25 ft. long, showing roller hearth furnace for normalizing and quenching, two pit type furnaces each 50 tons capacity for annealing, and a double chamber car type furnace for annealing or drawing

are a development from these brazing furnaces.

The enormous quantities of sheet, strip, wire and tin plate produced, offer a fertile field for efforts toward modernization of annealing equipment and extending the usefulness of electricity.

The use of such furnaces assures a cleaner and more uniformly annealed product, eliminates much labor in handling, saves floor space required for the storage of annealing boxes, and makes much cleaner surroundings and greatly improved working conditions.

These advantages can be secured at little or no additional overall cost for annealing, and in some cases, such for example as the coiled strip referred to, considerable savings may be realized.

Figure 13 is a general view of a plant for heat treating bar stock, 25 ft. long, of carbon and alloy steels. It shows, in the foreground, a roller hearth furnace with automatic charging mechanism and quenching crane for normalizing or quenching this bar stock, capacity 3 tons per hour. In the background, are two rectangular pit type furnaces for annealing, shown in more detail by Figure 14. These furnaces take charges of 50 tons of stock at a load.

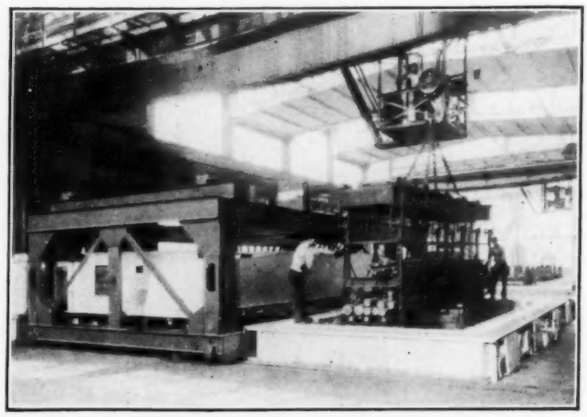


Fig. 14.—Two rectangular pit type furnaces, each 50 tons capacity, with cover of one moved aside by a special crane. Cradles for holding the stock are also shown.

In the background (Fig. 13) is a double chamber car type furnace for annealing or drawing, also for 25 ft. bar stock. This is an outstanding installation of electric furnaces, and it has operated with marked success.

Another outstanding installation is being made at the present time, consisting of 24 furnaces, each with 5 bases, as described, for annealing coiled strip. Numerous projects for annealing sheets, etc., are being considered also. These installations and projects indicate the tendencies in this field, and may be considered as a recognition of the advantages which these furnaces offer.

Discussion

Discussed By

Barton R. Shover, Consulting Engineer, Pittsburgh, Pa.

A. N. Otis, Industrial Engineering Dept., General Electric Co., Schenectady, N. Y.

Barton R. Shover: I'd like to ask a question. In the bright strip annealing you spoke about, what is the proportion of bottom and cover to the actual weight of material annealed, the weight of the cover that has to be heated to the same temperature as the material?

A. N. Otis: We put on about two and one-half tons of stock, and the cover will weigh about 200 pounds, as I recall it. I can't state it exactly, but that is about right.

B. R. Shover: You have a bottom that has to be heated.

A. N. Otis: That is a skeleton casting. It weighs about 300 pounds. The cover weighs about 200 pounds, and the casting that the stock rests on is about 300 pounds.

B. R. Shover: The proportion is not great, nothing like it is with the ordinary annealing.

A. N. Otis: It is very small by comparison.

J. J. Bowman: Assuming that the dissociated ammonia gas is a satisfactory gas for atomic welding, is electrolene satisfactory for the atomic hydrogen torch?

A. N. Otis: Yes, but it will require an adjustment of the torch due to the difference in the gases.

J. J. Bowman: How about using it as a straight gas torch?

A. N. Otis: I don't think I could answer that question as I am not sufficiently familiar with welding practice. The point in connection with the gas generating apparatus is this: You can't make electrolene producers in small sizes economically. About the smallest size you can make costs around $2,000, and for $3,000 or $4,000, you can get a fairly good sized outfit, while the ammonia outfits can be made in small sizes for a few hundred dollars.

With an atomic torch, you want a low cost outfit, of course, which will bear some relation to the cost of the welding equipment. The amount of gas used isn't large, so that a large producer would not be justified. The principle point is that the ammonia dissociator is a small, low cost equipment, and the electrolene is a larger and more expensive equipment.

J. J. Bowman: Your cost figures on gas,—60 cents for electrolene,—is that actual production cost of the gas including the cost of your gas and steam, or, does that figure cover only overhead charges for your equipment?

A. N. Otis: It includes the cost of the raw gas, the electric heat and the steam, but not the capital charges. In some places, gas is 60 cents; in some places 70 cents; while in other places it is 80 cents or more, therefore, you can't state an exact figure, for the cost of electrolene. The cost given was based on figures in our factory where we pay 70 to 75 cents for coke oven gas. We don't have natural gas. Natural gas is much cheaper, and it takes less energy to produce electrolene from natural gas than it does from coke oven gas. The increase in volume is also greater than with coke oven gas.

J. J. Bowman, Metallurgical Div., Aluminum Co. of America, New Kensington, Pa.

E. J. Poole, Jr., Prod. Engr., Carpenter Steel Co., Reading, Pa.

E. J. Poole, Jr.: I'd like to ask Mr. Otis if he gets any decarbonization on 1.20 carbon steel in electrolene atmosphere.

A. N. Otis: This matter is being investigated. It is indicated that the presence of methane in the atmosphere will prevent decarbonization. We all know that hydrogen does decarbonize. The way it decarbonizes is that it extracts carbon from the steel to form methane in the atmosphere. Only a small methane content however is required to establish equilibrium, on the order of 1 or 2 per cent so that if the correct atmosphere is maintained there should be no decarburization. The curve we had on the slide a while ago is an equilibrium curve. Dr. Campbell, I believe, suggested an investigation of this subject and Sykes carried the suggestion further to a laboratory study. He established this curve. It represents a condition of saturated atmosphere. For instance, with a 1.0 per cent carbon steel at 1,000 degrees centigrade, there is required say one per cent methane for equilibrium. If the electrolene has one per cent methane in it, it won't take any more carbon.

It is a rather difficult thing to investigate and get all the conditions just right to verify those laws, but that is the way the theory looks.

E. J. Poole, Jr.: Won't the composition of the electrolene vary?

A. N. Otis: By operating the electrolene producer at a higher or lower temperature, you can get any content of methane required. For our work, brazing, annealing, etc. We don't want methane, so we run the temperature high and crack it nearly all out. Regarding high carbon steels, we have annealed high carbon strip, and wire, in electrolene, .80 per cent carbon strip with one per cent methane in the atmosphere, with no evidence of decarburization. Methane in the atmosphere prevents decarbonization, as it tends to establish its own equilibrium.

Welding†

By A. B. ARGANBRIGHT*

In only recent years has the value of welding become fully appreciated. During the last comparatively few years various welding processes have come into their own, due partly at first to speed of production being an important factor, later proving to be more solid and giving more strength than riveting.

The subject of welding first applied to limited small parts, however it is now used for almost unlimited applications such as on various types of boilers, tanks, structural steel, and repair work by various ways of welding such as: gas welding, arc welding, resistance welding, and thermit welding.

Gas Welding

Gas welding is carried out by heat produced by the burning of acetylene in the presence of commercially pure oxygen.

Arc Welding

Arc welding may be divided into different classes such as, welding with bare electrodes, welding with coated electrodes, welding in a reducing gas flame, atomic hydrogen welding, carbon arc welding, electronic tornado welding, and automatic arc welding which are partly described as follows:

Bare electrode welding—An arc is struck between the electrode and the parts to be welded. The electrode being a wire rod of suitable composition. The metal is fused at both ends of the arc and the fused electrode deposited in the joint until it is properly filled. The welding may be done with either direct or alternating current, the alternating current being supplied by a suitable transformer provided with taps to adjust the current. However, there are several types of direct current arc welding equipment.

An arc welding outfit consists of a welding generator or transformer, a control for varying the current, a voltmeter and ammeter, proper lengths of cable, an electrode holder, and a suitable shield for protecting the eyes of the operator.

When direct current is used, one terminal remains positive and the greater portion of the total heat is liberated at this terminal. When alternating current is used the terminals are alternately positive and negative so that approximately the same amount of heat is liberated at each terminal. Usually the part to be welded is larger than the electrode so that its loss of heat will be greater and hence is made the positive side. However, when thin metal is being welded it is often advisable to reverse the polarity to prevent the arc burning through the metal.

Coated electrode welding—The idea of the coated electrode is to protect the wire from the atmosphere which affects the current in addition to the coating serving as a fluxing or deoxidizing medium. The coated electrodes are used either in hand, semi-automatic, or automatic arc welding.

Welding in a reducing gas flame—A cylindrical jet of gas surrounds the electrode and burns around the arc. Pure hydrogen and other gas combinations have been proven successful.

Atomic hydrogen welding—A fine jet of hydrogen is forced through an arc formed between two tungsten electrodes. The welding wire is fused in the flame and deposited in the joint.

Carbon arc welding—An arc is struck between the carbon electrode and the parts to be welded. The welding wire is fed into the arc and fused into the joint, or in some cases the welding wire is laid in the joint and the carbon arc passed slowly along the welding wire until the fusion is completed.

Electronic tornado welding—This manner of welding is conducted by a magnetically controlled carbon arc.

Automatic arc welding—Welding in this manner is similar to that of the hand arc except that there is a great advantage in the saving of labor and greater speed is attained. Also another great advantage is that the arc length and other variables are more accurately controllable and constant as compared to the most skilful hand operator.

Resistance Welding

The parts to be joined, after properly prepared, are pressed together and the current then passes through the joint until it has reached a welding temperature when further pressure is applied, which upsets the joint and completes the weld.

Thermit Welding

The parts to be united are first lined up with a space between the ends. The ends are thoroughly cleaned by some suitable means. A wax pattern is then formed around the ends of the exact shape of the thermit steel to be cast. A sand mould is next rammed around the wax pattern and inside a sheet iron box provided with pouring gates, heating gates and risers. A basin on top of the mould serves to act as a sink head when the pour is completed.

The subject of welding covers quite a wide field as brought out above by the different types of welding, of which each, we might say, is a subject in itself. However, of the four different processes only two require the most use of welding wire, namely gas welding and electric arc welding.

Welding Wire

The manufacture of suitable welding wire for either electric or acetylene welding attains its quality by the use of proper materials in the making, plus personal attention throughout the different stages of manufacturing.

In the making of steel in the Open Hearth furnace for welding wire, special attention is given to the selection of materials in their refining in order to insure the ingots produced being of best possible quality. The ingots are allowed to solidify, stripped, and charged into soaking pits for reheating to rolling temperature for rolling at Blooming Mill. At Blooming Mill, ingot is rolled into bloom of suitable size for bar mill, with sufficient discard taken at Blooming

† Presented before A. I. & S. E. E. Electric Heating and Welding Conference, Pittsburgh, Pa., January 21, 1931.

* Supt. Inspection and Tests, Wheeling Steel Corporation, Portsmouth, Ohio.

Mill shears from both top and bottom of ingot to insure steel free from piping and segregation.

The bars or blooms are then taken to Rod Mill for rolling into rods of proper size for drawing into finished wire for welding purposes.

In ordering rods for wire, sufficient size is given to allow proper drafting in Wire Mill.

The rods are then ready for cleaning and this is one of the most essential operations of wire manufacturing. Too much care can never be taken in applying the different methods of cleaning and preparing the rods for drawing. Rods on their arrival in Cleaning Department from Rod Mill have a hard black brittle oxide, commonly called scale which forms on the surface of hot rolled rods, also rust sometimes forms when long exposed to the air, both of which must be entirely removed before drawing, otherwise the holes in the dies would quickly cut out of shape and surface of the wire would be spoiled. After the rods are given a thorough cleaning in proper solution of sulphuric acid at correct temperature, they are rinsed into cold fresh water to remove the acid and dislodge any pieces of scale or other foreign substances adhering to the surface, dipped into slacked lime emulsion which neutralizes the acid and produces a coating for drawing.

The rods are then placed in bakers or ovens to thoroughly dry the lime coating, in addition to removing the so-called acid brittleness produced in the cleaning operation; i.e., a few hours baking at the proper temperature drives out absorbed hydrogen and the rod is restored to its original toughness. The rods are then ready for the first draft on the wire block.

The finished material is furnished in either bright, sul-coated or copper coated wire. Usually the bright and sul-coated wire is used by electric arc welding, whereas the copper coated wire is used mostly by acetylene gas welding. The bright wire is attained by special care in Cleaning House; i.e., after pickling it is rinsed in clear water and immediately dipped into lime, baked and drawn (dry) usually through soap powder. The bright wire is quite often given a patented coating by the trade, therefore the reason for using, as soap will clean more readily than grease.

The sul-coated wire is also gotten by procedure in Cleaning House. After pickling it is rinsed and then allowed to stand on sulling rack until rods have taken on sufficient rust, which gives a sul finish, dipped into lime, baked, and drawn (dry) usually through grease. The sul-coated wire is mostly supplied to the trade as bare electrodes.

The copper coated wire is termed as wet wire drawing, consisting of a thin plating of copper or an alloy of copper and tin, obtained by dipping the perfectly clean wire in solutions of the sulphates of these of these metals. For the copper coat the solution is prepared by dissolving blue vitriol in a suitable amount of water and adding a small percentage of sulphuric acid. This coating is done just prior to drawing the wire and is delivered to the Wire Department in the wet condition and immersed in barrels containing fermented liquor.

The bright, sul-coated and coppered wire are ordered to varying analyses, however the more common grades range from .04 to .18 carbon, with manganese content .10 to .60.

Inspection

The inspection of welding wire starts with the selection of steel and determined by reports made out by Open Hearth and Blooming Mill inspectors who report such information as: cast iron analysis, Open Hearth ladle analysis, Open Hearth charge in percentage time of heat, condtion in moulds, condition at pits, heating, rolling and production of heat.

The heat is then ready for rolling into rods at Rod Mill and rods are inspected for gauge and surface. From this point the inspection goes to Bundling Room where the wire is given a careful inspection (in coils) for gauge, coating, and fractured for piping in addition to the checking of heat tags to see that there is no mixed steel and varified by check analysis of samples taken from various trucks of wire.

The last test made on wire is by actual welding by an experienced welder and the welded specimens tested for ultimate strength and ductility. The weld itself tested for density and penetration.

Of course there are good and bad welding wires but so often conclusions are made which condemn the wire, and by careful check this, in many cases, has proven in error and the faulty weld attributed to causes such as human element, improper analysis of rod for part being welded, diameter of rod, and shop conditions or rather equipment. If these conditions are right the wire may be condemned account of either off analysis, piping, segregation, non-metallic inclusions, or ununiform coating which will cause a disturbance by the atmosphere.

In conclusion, a suitable weld should be produced if the welding wire is properly made, of proper analysis as ordered, and given the necessary attention in the manufacturing and in inspection, together with being used by competent help and proper equipment.

OBITUARIES

Edward G. Acheson, known the world over for his electric furnace products, died in New York on July 6, after a week's illness.

Michael P. Reagan, 63, for the past five years blast furnace superintendent for Struthers Iron and Steel Company, Struthers, O., died July 8 at Youngstown, O..

Joshua A. Hatfield, 68, president and director, American Bridge Company, New York, subsidiary of United States Steel Corporation, died July 4 in Presbyterian hospital, that city.

Richard Gilpin Wood, 83, former chairman of the Alan Wood Steel Company, Conshohocken, Pa., died June 30. He retired from active business three years ago.

Truman P. Gaylord, 60, vice president, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., died July 5 in Shelby, Mich.

Spraying System for Descaling Hot Steel

By J. E. HOLVECK*

Descaling of hot steel by means of spraying with high pressure water as the slab comes from the furnace and passes through the various stages of reduction in the mill, has developed a remarkable improvement in the quality of steel, mainly as to surface and finish. It has added an important stage in the process of manufacture to meet the rigid specifications of demand in this age of classified products. Any mill failing to perform this stage of the process cannot expect to meet those specifications nor compete with manufacturers who do.

The sprays extending across the width, top and bottom, flail the surface, thereby loosening the scale

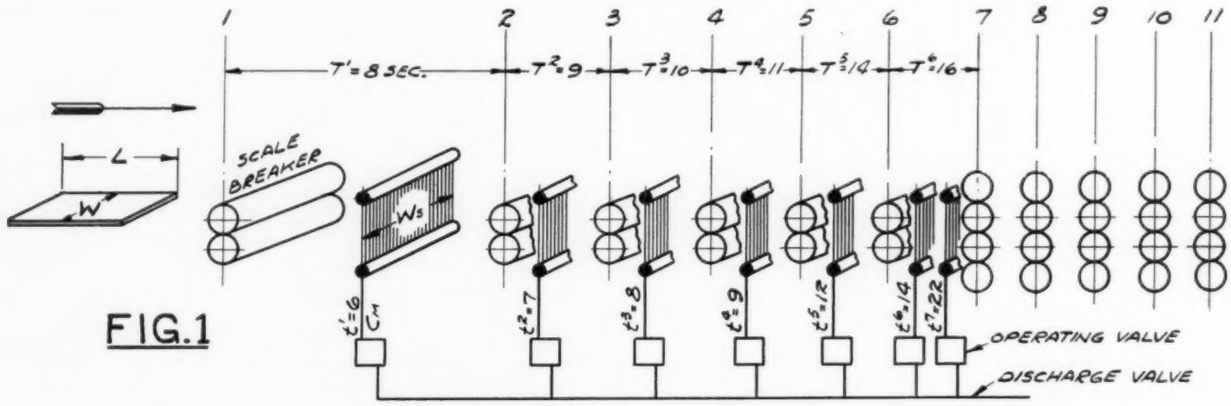


FIG.1

S = G.P.M. PER INCH WIDTH PER SURFACE
C_M = G.P.M. PER STAND OR PER PAIR SPRAYS
W = WIDTH OF SLAB
W_3 = WIDTH OF SPRAY
L = LENGTH OF SLAB

N = NO. OF STANDS SPRAYS APPLIED
t = TIME IN SECONDS SPRAY ON (t', t^2, t^3 ETC.)
t_1 = " " " " OFF (t_1, t_2, t_3 ETC.)
$T = t + t_1$ = TIME CYCLE PER SLAB (T', T^2, T^3 ETC.)
H = SLABS PER HR. = $\frac{3600}{H}$ = SECONDS OR $t + t_1$

FIG. 1.

after which it is readily washed off by the water. The sprays which are produced by a series of nozzles, therefore, perform two functions—first that of loosening the scale and second removing or washing it off. A third function may also be considered—that of reducing the temperature at certain final stages. Water very readily performs these functions when properly applied at sufficient constant pressure and quantity through well designed and efficient nozzles.

This article covers spraying as applied to a continuous strip mill, although its principles (with a few modifications) can be adapted to any other type of mill.

Figure 1, is a rough sketch of a continuous mill, showing the relation of rolls and sprays. The locations of sprays which may precede or follow its respective stand are shown as following the scale breaker and each stand of roughing rolls (up to the finishing rolls) then preceding the first finishing stand—seven pairs in number. This number may be considered as the maximum required. There may be five pairs or even as few as three in number. They may also be arranged in different order as shown in Figure 2. Regardless of how these sprays are arranged, certain characteristics always remain the same.

The proper application of these sprays can only be determined by the operating department who are in position to see the results obtained. There is a wide divergence of opinion among the superintendents and those responsible for the quality of the product, as to what this application should be. Those who have had experience in descaling with water have developed certain uses of this method with excellent results. To reach this stage has taken time and much experimenting. In a large majority of cases the spraying system at their disposal was not suitable since it was found that they were lacking in either an ample supply of water or sufficiently high constant pressure. These two essentials are the prime requisites of a successful descaling system.

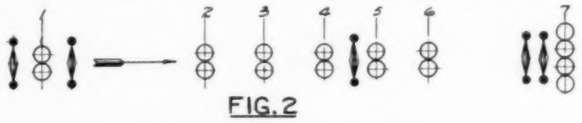


FIG. 2

There are a number of existing installations which undoubtedly will be replaced or revised. Where revision is possible the original installation in many cases will not lend itself to an economical change.

Data in connection with descaling has been gathered from experience in engineering and furnishing equipment for a large number of installations. These systems cover various types of mills—continuous, two high reversing, three high, blooming, bar, etc. Successful descaling is being extended to all

* Vice President, Aldrich Pump Co., Allentown, Pa.

branches of the steel industry relating to the initial rolling of slabs, plates, strip and other forms of steel shapes.

The purpose of this article is a study of this subject and a presentation of means for determining the actual water demand, in gallons per minute of requisite constant pressure, for the present accepted requirements of descaling.

Main Factors

The important factors effecting the water demand are:

1. The type of mill—time of slab passing through rolls at stands where spray is applied—time between stands—length of slab at each stand—width of slab.
2. Maximum number of slabs per hour
3. Maximum number of points sprayed with location of same.
4. Type of nozzle.
5. Value of (S) gallons per minute per inch width per surface.
6. Constant pressure.

Type of Mill

The first factor determines the on and off time of the sprays. The values as given in Figure 1 are an average of figures taken from a number of mills in service. It is assumed that all sprays are turned on only while the slab is passing the sprays. The time on of the spray is determined by the peripheral speed of the rolls in feet per minute and the time it takes a slab of a given length to pass through these rolls. The original length of the slab used in determining the time cycles for this particular mill is 6½ feet. We believe that the notations in Figure 1 are sufficient to determine the periods of time necessary in calculating demand charts shown in this article.

The second factor, the number of slabs per hour, is important as it determines the number of sprays on at one time. Figures have been compiled for 90, 60 and 30 per hour. With as few as three sets of sprays, they are certain to be located at the two most important points, 1 and 7, with any intermediate location, as for instance 5. For the mill under consideration, the relation of slabs per hour and sprays on at one time, is indicated as follows:

As per Figure 1:

Possible Number of Sprays on at One Time			
Sprays located at	**90 per hr.**	**60 per hr.**	**30 per hr.**
7 Stands			
1, 2, 3, 4, 5, 6, 7	3	2	1
5 Stands			
1, 3, 5, 6, 7,	3	2	1
3 Stands			
1, 5, 7	3	2	1
As per Figure 2:			
5 Stands			
1, 3, 5, 6, 7	5	3	2
3 Stands			
1, 5, 7	5	3	2

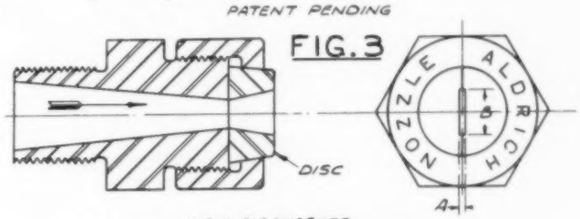
The number of slabs per hour also determines the time cycle per bar as shown by data under Figure 1. An important consideration in this connection is that while the average for one hour may be 30, a series of slabs may pass through the mill at the rate of 90, some at 60, and others at 30. Therefore, the rest periods occurring between each series must be of such length as to sum up to an average of 30. It is, therefore, apparent that the capacity of the system must be such as to take care of the maximum demand at any given time, of say 90 slabs per hour, and cannot be based on a low average of say 30 slabs per hour. This condition of wide variation in water demand is shown in Table 9.

Number and Location of Sprays

The third factor depends upon the results desired, that is: the degree of descaling necessary to meet the market desired. Location of sprays is important since better results may be obtained by one arrangement than another. Arrangement of sprays such as Figure 2, while requiring an average demand less than Figure 1 will require peak demands of 66-2/3% greater than values shown in Table 9 for arrangement as per Figure 1.

PATENT PENDING

FIG. 3



G.P.M. DISCHARGED

NOZZLE		PRESSURE-LBS. PER SQ. INCH					
A	B	500	600	700	800	900	1000
3/64"	1/2"	19.3	21.1	22.8	24.4	25.8	27.2
1/16"	1/2"	25.7	28.2	30.5	32.5	34.5	36.3

Nozzle

The type of nozzle is important and in a great measure responsible for thorough descaling. The impinging force, produced by the velocity and mass of water applied is that which loosens the scale. Velocity is readily acquired by the head or pressure, and to obtain maximum force, the body or mass of water must remain intact until it expends itself upon the steel. Another requisite of the nozzle is to distribute this force equally over its working range so that descaling is accomplished uniformly over the entire surface. The Aldrich nozzle, a recent development, as illustrated in Figure 3, was designed to answer these requirements.

The efficiency of a nozzle is determined by the ratio of the theoretical and the actual impinging force developed by the nozzle. On test the Aldrich nozzle shows an efficiency ranging from .90 to .95. This nozzle at .95 will produce 26% more force than one of .75 and for a given result will require 21% less water with equal pressure.

The form and action of the jet produced by the Aldrich nozzle is shown in Figure 4. Even after impact of the jet the water keeps in contact with the slab, thereby thoroughly washing off the loosened scale.

There is a question as to any advantage gained by directing the jet on the slab at any inclination other than a 90 deg. angle. The impinging force varies as the cosine of the angle of the jet with the slab. This indicates that the maximum force is produced with the jet at right angles to the slab as shown in Figure 4. An inclination of the jet may be desired in some cases to direct the loosened scale away from the rolls. If any inclination is made it should be as slight as possible, and the jet directed against the motion of the slab. In theory the impinging force is slightly increased with the jet directed against the motion

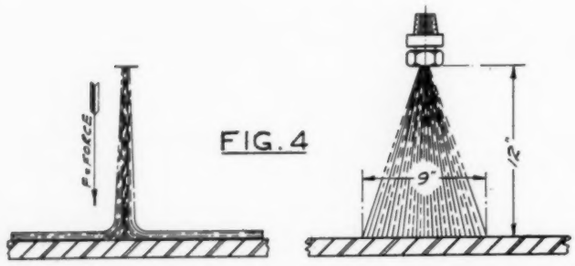


FIG. 4

of the slab and slightly reduced when applied with the motion. This is the resultant of the velocity components of the jet and the slab. Owing to the low velocity of the slab compared to the high velocity of the jet this influence may be disregarded.

This nozzle is furnished in two standard sizes, 3/64x½ and 1/16x½", delivering the quantities of water in gallons per minute shown in the table for given pressures. Both nozzles give an equal distribution of water over a 9" spread at a distance of 12".

Gallons Per Minute Per Inch Width Per Surface

Since force is in direct proportion to the GPM, either size may be spaced to give the desired results by either increasing or diminishing the GPM per inch of width. This is illustrated by Figures 5 and 6 with capacity Table #7.

These illustrations show a 3/64x½" nozzle having a capacity of 27 GPM at 1000# pressure. When spaced on 9" centers, the value (S) is 3 GPM: if, however, their centers are 6-¼", this value becomes 4.3 GPM, delivering 43½% more water and increasing by like per cent the impinging force on the steel per inch of width.

This changing of spacing makes it possible to easily vary the force using only one size of nozzle, to meet the requirements at different stands in the mill.

Figure 5, illustrates a spray pipe and its relation to the slab. This may be made with internal pistons for closing off end nozzles corresponding to the width of the slab.

Figure 6, is a plan arrangement of nozzles which

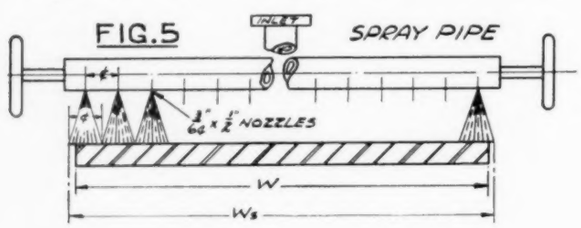


FIG. 5

can be varied to suit the conditions required.

Table 7, gives capacities in GPM for various combinations of slab widths and the value (S), for 3/61 x½" nozzle at 1000# pressure.

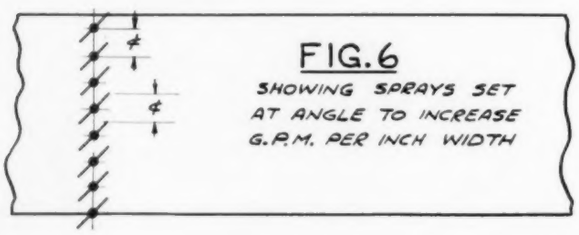


FIG. 6
SHOWING SPRAYS SET AT ANGLE TO INCREASE G.P.M. PER INCH WIDTH

As stated above mill operators are in the best position to determine the value (S), which with a given nozzle and pressure is the "measuring stick" for descaling. Furthermore, this value (S) is the only variable and once the points of spraying are

TABLE 7

S G.P.M. PER INCH WIDTH	W WIDTH OF SLAB	Ws WIDTH OF SPRAY	℄ NOZZLE CENTERS	NO. OF NOZZLES	CM/2 G.P.M. PER SPRAY PIPE	CM G.P.M. PER PAIR TOP & BOTTOM
5.2	72"	73½"	5¼"	14	380	760
	60"	63"		12	330	660
	48"	52¼"		10	270	540
	36"	36¾"		7	192	384
4.3	72"	75"	6¼"	12	322	644
	60"	62½"		10	270	540
	48"	50"		8	215	430
	36"	37½"		6	162	324
3.7	72"	72⅛"	7¼"	10	270	540
	60"	65¼"		9	243	486
	48"	50¾"		7	189	378
	36"	36¼"		5	135	270

selected, can be reduced or increased as shown in Table 7 to suit any degree of descaling desired.

It has been found that at certain stands, a greater value of (S) is required than at others. This may be high for the first stand and gradually decrease as the slab passes through the mill. As shown in Figure 2, this value is double at #1 and #7. In all cases where this value is used in this article, it is used as the average for all stands, excepting where otherwise stated.

In this article, 4.3 value for (S) has been selected, and if figures are desired for any other value they may be found by proportion. This value (S) in present installations varies from 3.5 to 8 GPM with the latter figure for the lower pressures. Where descaling has been only partially successful it has been due to a low impinging force resulting from a poor combination of nozzle pressures and values of (S).

Pressure

This important factor can only be determined after consideration in conjunction with, and its relation to,

IMPINGING FORCE, or degree of descaling.
GPM, or value (S).
PRESSURE, in pounds per square inch.
COOLING OF SLAB.

These four values are related to each other as follows:

Impinging force varies directly as the product of GPM, and square root of the pressure.

GPM varies as the product of area and the square root of pressure.

Cooling varies directly as the GPM.

The degree of descaling (IMPINGING FORCE) has been gradually advanced and at first this was accomplished by increasing the value (S) until it was discovered than an excess of water caused an excessive lowering in temperature of the slab. This

is not desirable when the slab is passing through the first stages of rolling where the percentage of reduction is high.

Pressures started at about 350#, then rose to 500#, then 700# and are now at 1000#. Each increase in pressure has given a higher degree of descaling, with equal GPM, and no greater loss in temperature. To maintain equal GPM it is necessary to reduce the

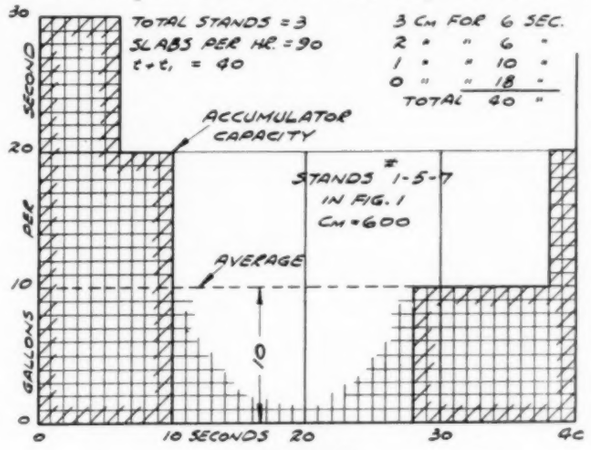


FIG. 8

area of the orifice inversely as the square root of the pressure. There is a limit to the reduction in area of the nozzle impairing its efficiency. Tests show this minimum orifice to be about 3/64x½ or 3 GPM per inch. This shows that any further increases in pressure beyond 1000# must be accompanied by greater values of (S).

Variable Water Demand

Figure 8, is a characteristic demand chart for a time cycle of 40 seconds or 90 slabs per hour, with sprays at three locations or stands 1, 5 and 7 for mill illustrated, Figure 1. This discloses the fact that the average demand is 1/3 that of the peak demand. For direct pumping with centrifugal pumps, of which a few installations have been made, the pump would be selected from this peak demand of 1800 GPM. In the Aldrich system the pump would be selected from the average demand of 600 GPM.

Applying the values of Chart Figure 8, to a condition from Table 9, for example: 90 slabs per hour, 72" width of slab with sprays at three stands requires:

		KW Hrs. Per Day
	1932 GPM— 6 seconds	
For direct pumping—	1288 GPM— 6 seconds—	17,200
	644 GPM—10 seconds	
	0 GPM—18 seconds	
For Aldrich System—	644 GPM—Continuous—	6460

It is evident that quite a saving in power is effected by the Aldrich system over that of direct pumping. This particular condition shows a saving of 10,740 KW hours per day, which at 8 mills per KW hour would be equivalent to $85.92 per day.

Table 9, is a tabulation of water demand for a continuous mill, the sprays arranged as per Figure 1. The figures are based on a value of 4.3 for (S). There is also shown the time cycle and capacities for both direct pumping and the Aldrich system.

TABLE 9

TABLE SHOWING G.P.M. DEMAND FOR DIRECT PUMPING WITH TIME CYCLE AND G.P.M. DEMAND FOR ALDRICH SYSTEM, FOR CONTINUOUS MILL AS PER FIGURE NO. 1
PRESSURE = 1000 LBS. PER SQ. INCH

S GALS. PER INCH WIDTH OF SURFACE	W WIDTH OF SLAB INCHES	Cm G.P.M. PER STAND TOP AND BOTTOM	7 STANDS DIRECT PUMPING G.P.M.	7 STANDS DIRECT PUMPING SECS.	7 STANDS ALDRICH SYSTEM G.P.M. CONT.	5 STANDS DIRECT PUMPING G.P.M.	5 STANDS DIRECT PUMPING SECS.	5 STANDS ALDRICH SYSTEM G.P.M. CONT.	3 STANDS DIRECT PUMPING G.P.M.	3 STANDS DIRECT PUMPING SECS.	3 STANDS ALDRICH SYSTEM G.P.M. CONT.
4.3 90 SLABS PER HOUR t+t,=40	72	600	1932	6	1200	SAME AS 7 STANDS	6	1000	SAME AS 7 STANDS	6	644
			1288	6			14			6	
			644	10			16			10	
			0	18			4			18	
	60	540	1620	6	1053		6	837		6	540
			1080	6			14			6	
			540	10			16			10	
			0	18			4			18	
	48	450	1290	6	845		6	620		6	430
			860	6			14			6	
			430	10			16			10	
			0	18			4			18	
	36	324	972	6	600		6	500		6	324
			648	6			14			6	
			324	10			16			10	
			0	18			4			18	
4.3 60 SLABS PER HOUR t+t,=60	72	644	1288	24	840	SAME AS 7 STANDS	14	600	SAME AS 7 STANDS	40	435
			644	30			34			20	
			0	6			12				
	60	540	1080	24	700		14	558		40	362
			540	30			32			20	
			0	6			12				
	48	450	860	24	560		14	443		40	288
			430	30			34			20	
			0	6			12				
	36	324	648	24	420		14	335		40	215
			324	30			32			20	
			0	6			12				
4.3 30 SLABS PER HOUR t+t,=120	72	644	644	78	620	SAME AS 7 STDS	62	330	SAME AS 7 STDS	40	218
			0	42			28			80	
	60	540	540	78	351		46	278		40	181
			0	42			28			80	
	48	430	430	78	280		46	222		40	144
			0	42			28			80	
	36	324	324	78	212		62	167		40	109
			0	42			28			80	

Any condition selected from this Table shows saving in power cost by the Aldrich system ranging from 1/3 to 2/3 of the direct pumping system.

Figure 10, shows a demand chart covering a condition of spraying which may be desired and which shows the wide variation of water demand possible in a spraying system. This is not an extreme case but rather one which may be demanded by the mill operators as necessary to give desired results. The average demand in this case is less, but the peaks far greater than the maximum demand for Figure 1.

Figures below this chart are based on a condition of 90 slabs per hour; S equals 4.3, W equals 72" and sprays applied as per Figure 2. This shows that this condition would require three 1000 GPM centrifugal pumps with a total of 2700 HP. motors as compared with the Aldrich system of two 600 GPM pumps having a total of 800 HP. motors.

The KW hours consumption shows a difference of 10,480 KW hours saving which at 8 mills per KW hour would be equivalent to $83.84 per day. Saving would also be effected in lower demand charge in power plant and first cost of complete installation.

It will be seen that two 600 GPM pumps originally installed on the Aldrich system for condition in Figure 1 would also answer condition for Figure 2. The selection, however, of two 1000 GPM centrifugal pumps for Figure 1 would not answer the condition in Figure 2 but would necessitate the installation of an additional third unit of 1000 GPM capacity.

Characteristic of Water Demand

Charts 8 and 10, also Table 9, indicate the characteristic variable water demand of a continuous mill, showing that this demand does not vary gradually but in steps of increasing or diminishing capacity rates in multiples of the value C_m. Referring to Table 9 for 72" width of slab, the water demand

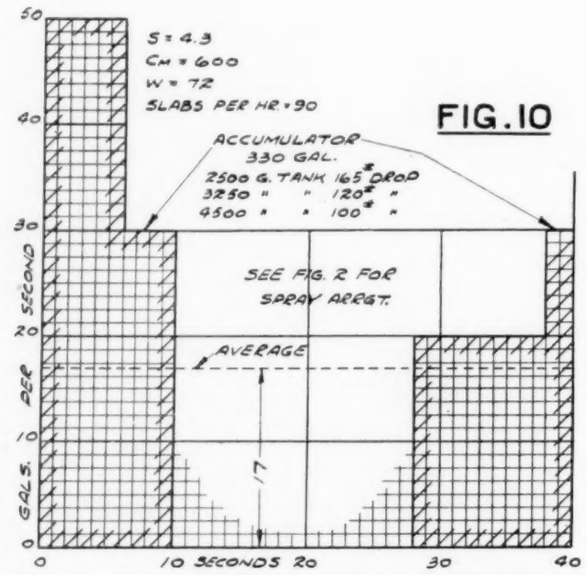


FIG. 10

	G.P.M.	TIME	PRESS.	PUMP EFF.	SHAFT HP.	AVERAGE INPUT KW.	KW. HRS. PER 20 HR. DAY
DIRECT PUMPING 3-1000 G.P.M. CENT. PUMPS 3-900 HP. MOTORS	3220	6	1000	70%	2680	1110	22,200
	1932	6	1100	63%	1780		
	1298	10	1120	40%	1880		
	0	18	1140	0	323		
ALDRICH SYSTEM 2-600 G.P.M. RECIP. PUMPS 2-400 HP. MOTORS	1095	CONT.	1000	88%	788	586	11,720

varies as the multiple of the capacity rate of 644 GPM, or

O, C_m, $2C_m$ and $3C_m$=O, 644, 1288, and 1932 GPM for 90 Slabs per hour.

O, C_m, and $2C_m$=O, 644, and 1288 GPM for 60 Slabs per hour.

O, and C_m=O, and 644 GPM for 30 Slabs per hour.

Other types of mills have a similar characteristic differing only in the number of steps of the capacity rate, from zero and C_m, to zero and nC_m.

Pressure Drop or Losses

The loss in pressure due to friction in pipe lines and operating valves has been neglected in the previous chapters. This, however, was not with any intent to minimize its influence upon the system. The ratio of the pressure at the nozzle and at the source is the measure of efficiency of pipe line.

To realize minimum losses, ample size pipe lines are required as well as large size operating valves. The pipe sizes should be selected from the peak demands shown in graphs, Figures 8 and 10; also the flow C_m to each pair of sprays. The operating valves should be determined from the value C_m, and a valve selected with a low pressure loss.

The main considerations for a successful spraying system for descaling hot steel may be briefly summed up as follows:

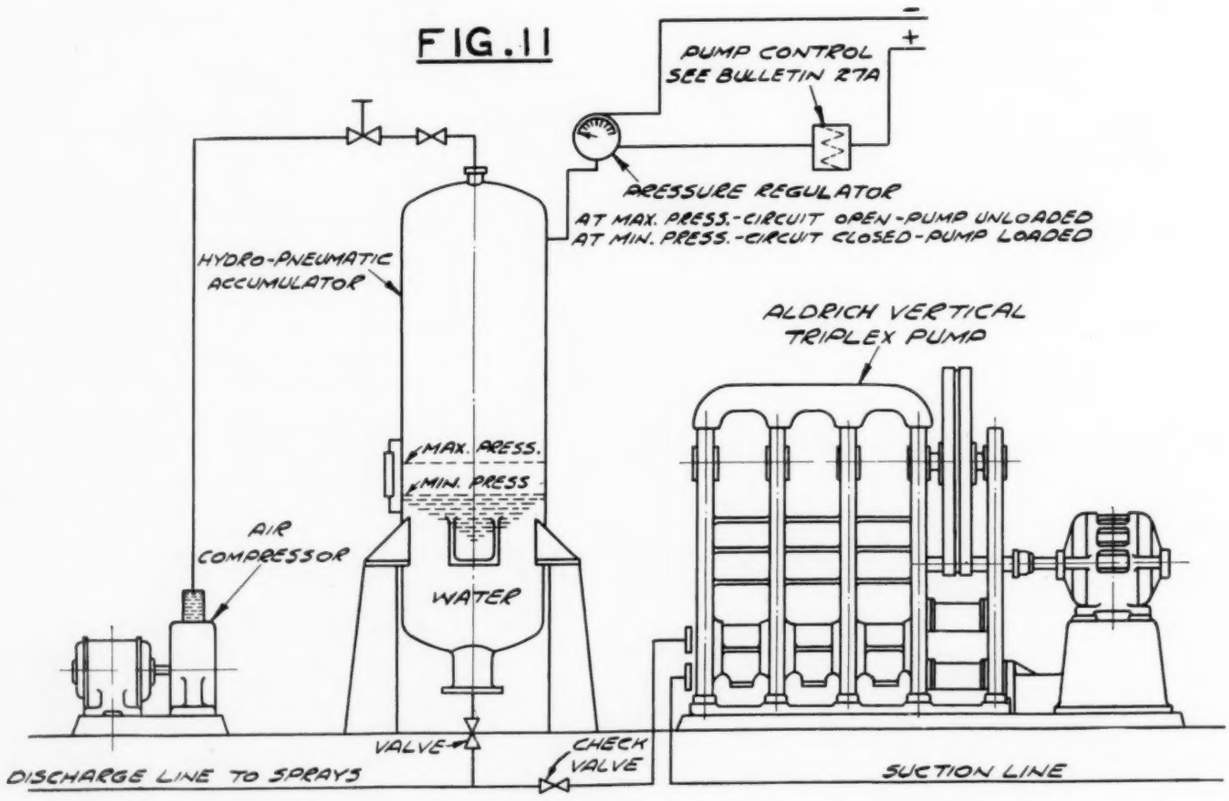
Pressure

The water pressure should be sufficiently high and constant. It should be possible to vary this pressure for different degrees of descaling.

Capacity

The quantity of water is determined from the

FIG. 11



value (S) or GPM per inch width. This value is determined from experience and should be selected with ample allowance.

System

The system selected should be capable of automatically supplying the water demand. It should be flexible to meet the varied demands of the mill operatives, giving them unlimited choice in the selection of the value (S), pressure, number of sprays, and location of sprays.

The selection of equipment should be based on these principal factors, and should be such as to answer all the requirements for complete and thorough spraying system.

Aldrich System

The Aldrich System operates economically for all conditions and any additions thereto can be made with the assurance of continued low power cost and maintenance.

Figure 11, illustrates the Aldrich System, consisting mainly of one or more reciprocating type of pumps equipped with Synchronized Suction Valve Control in conjunction with an Hydro-Pneumatic Accumulator.

This system of supplying pressure water with but slight fluctuations in pressure readily meets the demands outlined above. It not only takes care of the variable average demand but most importantly the short peak demands shown in the charts of 100% to 300% above the average.

The accumulator which is a simple pressure vessel, is charged originally with approximately two-thirds air and one-third water by volume. With this ratio, it has a fixed amount of accumulated water dependent upon the total volume of the tank and the drop in pressure. At 1000# maximum and 900# minimum, a vessel of 2500 gallons in volume will discharge approximately 7½% of the total volume or 187½ gallons of water.

The Accumulator may be charged by a separate motor driven air compressor. Another charging device eliminating the air compressor, developed by the Aldrich Pump Company consists of a special arrangement of tank in combination with Synchronized Suction Valve Control and the Pump. The Accumulator requires infrequent charging as little air is lost and that only by absorption. It is not necessary to adhere strictly to the ratio of air and water, since the system will operate satisfactorily on a ratio of one-half air and one-half water. This reduction in air volume would effect only the pressure drop in the extreme cases of large peak demand.

The Pump operated by a synchronous motor, runs continuously but is loaded and unloaded in accordance with the demand. A Synchronized Suction Valve Control which functions by means of a solenoid and a pressure regulator makes this simple control arrangement possible. The electric pressure regulator, connected to the air side of the vessel opens the control circuit unloading the pump at the maximum pressure and again loads the pump at a lower pressure. The loading and unloading occurs in the regular cycle of the pump characteristic, and is accomplished without shock or loss of pressure water. This is illustrated in diagram Figure 12 of a triplex single acting pump.

FIG. 12

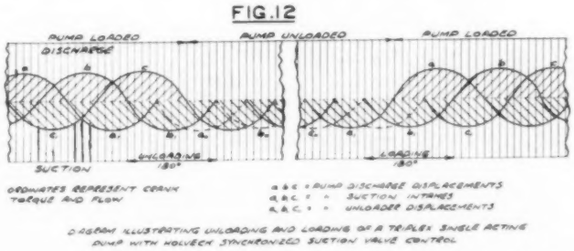


DIAGRAM ILLUSTRATING UNLOADING AND LOADING OF A TRIPLEX SINGLE ACTING PUMP WITH HOLVECK SYNCHRONIZED SUCTION VALVE CONTROL

Each plunger ceases to discharge at the end of its stroke and again begins discharge at the beginning of its stroke. Unloading takes place with a gradual diminishing discharge and torque, to zero—and loading takes place from zero, with a gradual increasing discharge and torque.

Frequency of loading and unloading is immaterial, since this is accomplished as in normal operation when loaded. The power consumption at no load is only 8 to 10% of the normal, so that efficiency for less than full capacity is high as shown in Table 13.

TABLE 13

TABLE SHOWING PUMPING EFFICIENCIES FOR THE ALDRICH SYSTEM WITH TWO 600 G.P.M. PUMPS WITH LOADING AND UNLOADING PERIODS.
THE G.P.M. IN COLUMNS UNDER ALDRICH SYSTEM IN TABLE 9 DIVIDED BY 1200 GIVES THE PERCENT DEMAND CORRESPONDING TO PERCENT DEMAND IN THIS TABLE.
CONDITION IN FIG. 10 WOULD BE $\frac{1095}{1200}$ = .91 OR 90% CLOSELY IN THIS TABLE.

PERCENT DEMAND CONTINUOUS DUTY	PUMP A			PUMP B			COMBINED PUMPING EFF.
	EFF. PUMP ALONE	PUMP LOADED TIME	PUMP UNLOADED TIME	EFF. PUMP ALONE	PUMP LOADED TIME	PUMP UNLOADED TIME	
100	.88	CONTINUOUS		.88	CONTINUOUS		.88
90	.88			.855	80%	20%	.868
80	.88			.815	60%	40%	.848
70	.88			.746	40%	60%	.813
60	.88			.595	20%	80%	.738
50	.88			0		100%	.78
40	THIS PUMP AUTOMATICALLY SHUT DOWN			.855	80%	20%	.855
30				.815	60%	40%	.815
20				.746	40%	60%	.746
10				.595	20%	80%	.595
0				0	0	100%	0

This Table also shows complete range of operation with pumping efficiencies of two Aldrich pumps, each having a capacity of 600 GPM or a total of 1200 GPM, selected to cover the complete range of water demand in Table 9, and also condition of graph Figure 10. For 1000# working pressure, each pump would require a 400 HP. Synchronous motor.

The combined efficiency is given for the entire range from 0 up to 100%.

With this system, it is possible to change the pressure by a simple adjustment to the pressure regulators. This may be desired where a lesser degree of descaling is required for lower grades of strip, and would conserve power and reduce cost of production.

The pump is a vertical single acting type, either triplex or quintuplex, as illustrated in photo Figure 14. Many up-to-date features are incorporated in

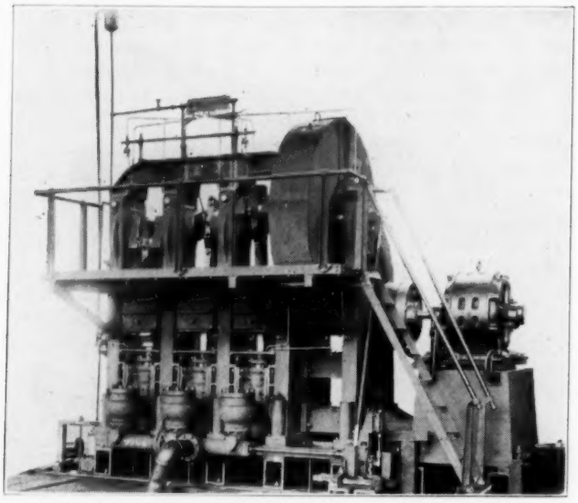


FIG. 14.

their design to insure continuous service at minimum up-keep. A few of these features are as follows:

Herringbone Gears running in oil with oil tight casings.
Chilled iron or hardened steel plungers.
Automatic lubrication of bearings.
Forged steel one-piece crankshaft.
Low bearing pressures.
Roller bearings for pinionshaft.
Holveck Synchronized Suction Valve Control.

The operating valves indicated for controlling the spray water should be such as to withstand frequent operation at minimum maintenance. The opening and closing of this valve which is always against pressure, should be controlled by an adequate throttling device to prevent excessive shocks. This necessary action creates a condition of wear on valve and seat, unless counteracted in some way.

The means for opening and closing should preferably be automatic to insure against the excessive use of water. A development recently put into service by the Homestead Valve Manufacturing Company, with a General Electric Thrustor, holds promise of favorable automatic control. Another arrangement of solenoid pilot operated valves lends itself to automatic action.

Discussion

*Industrial Power Applications**

Joint Meeting A. I. & S. E. E. and A. I. E. E.

March 13, 1931

"Conversion and Distribution of General Purpose D.C. Power in Large Industrial Plants," by R. D. Abbiss, Assistant Chief Engineer, Carnegie Steel Company, Braddock, Pa., and D. C. West, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

"Interconnections of Power Between Public Utilities and Large Industrial Users," by F. O. Schnure, Superintendent of Electrical Department, Bethlehem Steel Company, Sparrows Point, Md.

"Interconnection Between the Duquesne Light Company and the Davison Coke & Iron Company," by G. E. Dignan, Chief Engineer, Davison Coke & Iron Company, Pittsburgh, Pa., and R. L. Kirk, Assistant to System Development Manager, Duquesne Light Company, Pittsburgh, Pa.

"Absorption of By-Product Power," by A. Hoefle, Engineer, Toledo Edison Company, Toledo, Ohio, and W. T. Woodmancy, Superintendent of Power, Interlake Iron Corporation, Toledo, Ohio.

Discussed by

A. C. Cummins, Electrical Superintendent, Carnegie Steel Company, Duquesne, Pa.
B. M. Jones, Planning Engineer, Duquesne Light Company, Pittsburgh, Pa.
E. M. Melton, General Electric Company, Cleveland, Ohio.
H. L. Wallau, Cleveland Electric Illuminating Company, Cleveland, Ohio.
E. C. Merrick, Industrial Engineering Dept., General Electric Company, Schenectady, N. Y.
G. W. Baumgarten, Assistant to Electrical Engineer, Carnegie Steel Company, Duquesne, Pa.
E. S. Fields, Manager Electric Dept., The Union Gas & Electric Company, Cincinnati, Ohio.
W. H. Rodgers, General Engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
M. R. McConnell, West Penn Power Company, Pittsburgh, Pa.
F. O. Schnure, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Md.
M. H. Morgan, Electrical Engineer, Carnegie Steel Company, Braddock, Pa.
J. W. Bates, Electrical Engineer, Power Division, American Sheet & Tin Plate Co., Pittsburgh, Pa.

A. C. Cummins: The papers that have been presented should be of particular interest to the engineers of the steel industry, as well as those who are interested in supplying energy for general industrial use. In recent years, there has been a large increase in the power requirements of industrial plants. This has been particularly true in the steel industry and has made the purchase of electrical energy or its generation of major importance in controlling the cost of the product.

The greater use of electricity has also placed greater importance on the utilization of by-product

*These papers appeared in March, 1931, issue of Iron & Steel Engineer.

heat economically, and has likewise tended to emphasize the importance of the problem of sufficient and economical distribution of electrical energy within industrial plant boundaries. A modern solution to the problem of distribution has been well outlined in the paper that has just been presented by Mr. Abbiss and Mr. West.

The other papers of this morning discussed the matter of improving the economy of the utilization of by-product heat by means of interconnection of the electric power producing facilities of industrial plants, either with other industrial plants or with the public utilities. The demand for electric energy for industrial purposes is subject to much irregularity. Likewise many industries have by-product heat available but with fluctuations in the supplies of such heat and inasmuch as the fluctuation in the demand for electric energy and in the supply of by-product heat usually are not synchronized, there has been much difficulty in efficient utilization. This condition is particularly true in those industries where the by-product heat is available in gaseous form of low thermal unit content and thus impractical to store. Industry has been somewhat slow to appreciate the possibilities of interconnection as a means of eliminating the wide differences between supply and demand for by-product energy, and the broad benefits which are derived from a suitable interconnection either as between industries or between industry and the public utility. For this reason, a discussion of this subject, participated in by both the engineers of the public utility corporations and those of the industries who have already adopted this method of solving the problem, should be of particular interest.

There are a number of gentlemen present this morning who are well qualified by their experience to discuss all of the papers that have been presented. We will call first upon those who have prepared discussions to present and later open the meeting to a general discussion of the subject or any questions that may develop. We will first call upon W. B. Skinkle of the Pittsburgh District Power Committee of the United States Steel Corporation to present his discussion.*

B. M. Jones: The papers presented today on interconnections are very apropos as the utilization of waste energy in any form is receiving more and more attention with the prime object of saving money.

The day of economy is at hand and economic wastes either by an industrial plant or by a utility are unpardonable in this day and age, particularly during these times when all plants are struggling to avoid a deficit, and while two of these papers do not say so in specific figures, there are, I am sure, material savings in money resulting from such interconnections.

The interconnections between large industrial users and central stations are little different than interconnections between utilities, for some of the same salient features prevail, such as excess generating capacity on one system, more economical plants on one system, utilization of water power, elimination of transmission losses, reserve or standby generating capacity or line capacity, etc.

I was quite interested in Mr. Schnure's paper as I have been reasonably familiar with the Sparrows Point Plant, and have been in and through this plant many times.

In this paper the figures were quite interesting relative to the amount of kilowatt capacity that could be obtained from one modern 1000-ton blast furnace which was of the order of 25,000 kilowatts when using gas engines, and 20,000 kilowatts when using modern boilers. This lower figure for the modern boilers seems quite surprising, and I am wondering what the modern boiler makers and modern power plant designers would say to this lower figure as compared to gas engines. They should bestir themselves to get their equipment up to the efficiency of the gas engines as shown in this paper.

There was also another comment in Mr. Schnure's paper relative to the utilities promoting the use of power from waste heat gases of steel plants by offering attractive rates. I personally feel that no rate should be offered that does not allow a profit to both companies, for in the end the economies must prevail, and any arrangements not providing a profit will certainly return to haunt the makers of such arrangements.

All of us recognize that a steady, even load factor permits of conditions in no way comparable to the peak load use of power, and that any industrial plant interconnected with a utility and calling on the utility for peak power only, should be expected to pay more than for a constant load; and similarly, any utility taking only surplus power from an industrial plant should be expected to pay less for it than if they received power on a base load plan. It is well recognized that the values of standby or emergency power supply are worth some money, and in some cases worth an appreciable amount, and this feature should certainly be carefully considered and allowed for in any interconnection.

In the first part of Mr. Schnure's paper, reference is made to many industrial plants that can operate satisfactorily with a power contract which permits the utility, **after due notice,** to curtail the amount of power which the plant takes on any day or even during certain hours of any one day. While this may appear advantageous, desirable and easy to adhere to at the time of making the contract, this clause may bring on great embarrassment, inconvenience and misunderstanding, for it is one thing to tool up your industrial plant and set up your operating order to take power from a utility if, as and when the utility power is available, but another thing to suddenly find the utility calling up restricting your use of power. This must be given full and complete consideration, and while it may be written in the contract that restrictive measures can be executed, it is very important that the entire operating organization of the industrial plant appreciates this fact and recognizes it so that there will be no misunderstanding when you have to shut down some of your mills due to the limited power available.

There are many interesting features in connection with such interconnections, such as protective features in the way of larger oil circuit breakers resulting from the tie-in with the large utility's system, thus imposing greater short circuit duties on the industrial plant equipment, also the surges of several kinds to which the industrial plant electrical

* Mr. Skinkle's discussion appeared in the May, 1931, issue of the Iron and Steel Engineer.

system may be subjected as a result of the many, many more miles of transmission lines scattered over the country, together with the ever present and important relay protectiye schemes to allow satisfactory operation of the interconnection.

One of the interesting features of Messrs. Hoefle and Woodmancy's paper was the date at which this interconnection was first made, which was in 1924, and shows that somebody in these organizations was alive to the utilization of waste energy at that time and actually set about to utilize it economically. It is further stated that after five years of experience the two parties are able to report satisfactory operation and no unusual problems, which further emphasizes the fact that such interconnections can be accomplished.

Under the subject of operation, it is pointed out that for the first year and a half this connection did not provide entire satisfaction to either party for the furnace plant secured only partial utilization of its by-products and failed to realize the operating economies expected. I believe that this feature is very important and worthy of a considerable amount of attention by other utilities and industrial plants considering an interconnection, for similar conditions may arise in many cases and undoubtedly will arise in other cases. It is shown that after the first year and a half, an extension to the generating equipment of the industrial plant was made and at that time the advantages and economies expected were realized.

I believe that installing larger generating units in some cases by the industrial plant, and the delivering to the utility of the excess energy over the immediate industrial plant requirements, will provide economies to both companies providing a suitable agreement can be made, and that as the industrial plant load grows, the utility will take less and less energy and then will actually deliver energy to the steel plant until such time as they, the steel plant, can justify the installation of the next generating unit. At this time the cycle can be started all over again. I believe that some thought can be put on this phase of the interconnection situation with resultant benefits to both the utility and the central plant.

E. M. Melton: Mr. Schnure's paper seems to be very comprehensive, especially when consideration is given to the fact that the whole subject of interconnections of power between public utilities and large industrial users is covered in a general method.

My discussion of this paper will be confined to the three plans which have been outlined.

In the first plan (industrial receives all of its electrical energy from the public utility) mention is made of the public utility or central station encouraging large industrial customers to avail themselves of lower power rates through avoidance of peak load period of the utility. There have been several instances where central stations have promoted this type of load balancing to the point where an off-peak period has become almost as high as the peak period which they were trying to avoid. This situation, of course, means that the central station must exercise close supervision to insure that such a condition does not occur.

In line with this first plan it has been demonstrated that economies can be effected by the large industrial user if special process work such as electric heat treatment of certain products can be done in the off-peak period of the central station.

In discussing plan 2 (central station furnishes peak load and industrial generates the base load), it is apparent that in many cases this plan is quite satisfactory if the proper application is made after thorough study of the power available from by-product and waste heat sources.

One interesting interconnection of a 5000 KW turbo-generator set in an industrial plant (based on plan 2) reveals the following figures for a period of two months' operation:

	April, 1929 KWH's	May, 1929 KWH's
Purchased power	1,784,000	976,000
Generated power	1,152,000	2,410,000
Sold to Utility	120,000	86,000

The power rate (energy charge) was approximately 7 mills for the purchased power—and the industrial received approximately 4 mills for the power sold to the utility. This latter block of power was sold to the utility over the week-ends or off-peak period, for the most part.

An installation of outstanding interest in regard to this subject of power interconnection is the new $4,000,000 mercury-vapor power plant which will be designed and erected by the General Electric Company in Schenectady, N. Y. This plant will be leased to the New York Power and Light Company. It will then be used to supply energy to the latter company's transmission system and it will also supply steam for heating, testing and process work in the General Electric Company plant at Schenectady. The General Electric Company will purchase a part of its electrical energy from the New York Power and Light Company and has also arranged to furnish energy in emergency to this utility.

H. L. Wallau: The complete elimination of waste would doubtless go a long way toward solving many of our economic problems. The interconnections described in the papers presented today indicate that co-operation between steel plants and utilities result in very practical benefits to both, which must ultimately benefit the community at large.

With the concentration of industry which has been and is still taking place, small plants are being replaced by large ones in almost all lines. In many industries process steam and hot water are required for manufacturing and a considerable quantity often for heating purposes. It is well known that these process and heating requirements cannot be so coordinated with motive power requirements so that a balance continually obtains between the two. Hence, there are periods when excess power can be furnished from an industrial plant with profit to it and other periods when the purchase of excess power requirements by the industrial is distinctly advisable, in order to minimize the investment in local power production equipment. It would, therefore, seem that there will be developed an increasingly strong economic trend leading to such interconnections, economically profitable to the parties involved and in addition providing a greater safeguard for reliability of power supply to both.

Cases will also arise in which a supplementary power supply from a utility without power interchange will make for maximum economy. No firm

rule can be laid down—each case will require careful analysis to determine the conditions that govern and the best way of meeting them.

In reference to Mr. Hoefle's paper, it was rather interesting to notice that during the weekdays that load factor of the firm power supplied by the Interlake Iron Corporation is about 82½ per cent, and that the average load factor for the whole week was in the neighborhood of 75 per cent, which indicates that the base load carried by that industrial plant is a very satisfactory one and that the total power cost for their own surplus generation must be rather low, because of the base load on which their own local requirements are superimposed.

E. C. Merrick: Although much has already been done in the way of interconnections between utility and industrial systems, there remain many possibilities of such ties which could be made to the advantage of both parties.

It was not many years ago that the large industrial organization was very skeptical of the advisability of an electrical tie with the utility company; this attitude was due partly to the unreliability of the utility supply and partly to the instability of power rates. Modern methods of generation and transmission on the one hand and rate regulation on the other have gone far toward the removal of these past prejudices.

The barrier to interchange of power has been the lack of appreciation on each side of the other's operating problems. It is interesting to learn from the papers presented at this meeting how, with close co-operation, interconnecting arrangements can be made by the two parties which are mutually advantageous.

It may be asked, "Where does the electrical manufacturer fit into this discussion?" Is he interested one way or the other in the outcome? Will the economies resulting from interconnection affect his sales? I believe he is very greatly interested and very desirous of co-operating in every way to make these ties effective.

In the past, the manufacturer has filled a somewhat difficult role; assistance which he might give to either party could easily affect decisions inimical to the interests of the other. With both parties working together in a common cause, he can feel entirely free to recommend the use of whatever equipment will best satisfy their mutual interests.

Each case of interconnection presents an individual problem, not only in regard to rate and peak load adjustments, but also in regard to the type of apparatus which should be used to give the desired results. It is in the development of such equipment that the manufacturers can play a very important part.

This pooling—so to speak—of the power resources of the utilities and industrials may possibly result initially in some reduction in large apparatus sales; ultimately, however, the effect of these interconnections will be to greatly stimulate electrification of the industries and the manufacturer, as well as the principals, should profit accordingly.

G. W. Baumgarten: Fellow Members and Guests: I felt quite at home when I read Mr. Abbiss' and Mr. West's paper on the distribution of D.C. power. Their references to large steam-driven D.C. generators and one reference to the floating storage battery reminded me of some relics that we had at a plant with which I am familiar. Our system, of course, is dependent upon the geographical features of the plant and the load distribution. Therefore, it is quite different from the system developed at the Edgar Thomson Works. There are some features, wherein they differ which may be of interest to those of you that are connected with the steel industry. We have two D.C. substations, containing M.G. sets which are manually operated, although they are connected by two heavy tie lines; these tie lines supply the ore bridge and skip hoist loads. Due to the arrangement of our plant these tie lines are 2500 feet long, and due to the load on the tie lines, one tie line feeding a 2100 horse power connected load, and the other a 5200 horse power connected load; the tie line in one case requires four million C.M. and in the other case eight million C.M. These two substations operate primarily in parallel. The M.G. sets are compound wound, with a flat characteristic, and are naturally equipped with an equalizing bus. There are no system regulators in use at these substations at all, as they are completely manually operated. However, we have no difficulty in operating these two substations in parallel, as compared to the arrangement with Edgar Thomson. All of our outgoing feeders are encased in lead-covered cable to the bottom of the outgoing tower; from there on, of course, it is waterproof insulation. I would like to say that while the other system, to my mind, has advantages, from a steel mill point of view I feel it also has disadvantages. There may be economies, as far as the saving in distribution losses is concerned, and also in the reduced maintenance force required, but in addition one has this more or less complicated load regulating equipment, which may possibly give trouble, and requires more or less skilled repairmen, who must be constantly on the watch to keep it in good operating condition. As far as our system is concerned, during the six years that I have been familiar with it, we have only had one substation shut down, and that was an occasion when a repairman hunting for trouble accidentally pulled some potential fuses which controlled a no voltage relay, and of course shut down the substation.

E. S. Fields: I should merely like to make reference to two interconnections between industrials and the Electric Utility Company in the Cincinnati district which are operating at the present time. They are of a somewhat different character than those that have been described today. One of these is the Champion Coated Paper Company at Hamilton, O., a paper mill with an installed generating capacity of about 25,000 kilowatts with a load of somewhere between 12,000 to 15,000 kilowatts. This interconnection operates as a heat balance proposition, the amount of power generated by the industry being determined by the amount of steam required for the processes. Any deficiency in the motive power requirements is supplied by the utility, and under the reverse condition, any excess energy generated due to excess steam requirements is absorbed in the system of the utility. In general, the power flows from the industrial plant into the system of the utility company during the winter season; in the summer time, when the requirements for steam are less, and on Sundays and holidays and so forth, the

power flows in the reverse direction; that is, from the utility to the industrial.

We have another type of installation in the Cincinnati district which involves an industry which has developed a hydro electric plant. This is at the plant of the Ford Motor Company also at Hamilton, O. This hydro plant is on the Great Miami River and there is a wide variation in the flow of water in the river from one season to another. The demand for power for manufacturing purposes is practically constant, so the interconnection permits the delivery of energy from the electric utility to industrial when there is a deficiency of hydro energy and in the reverse direction when there is an excess of hydro energy available. This is a very small installation, 2250 kilowatts of capacity.

I should like to agree with the gentleman who made the comment that the problem of interconnection between industrials and electric utilities presents no difficult engineering problem. The chief problem is a commercial one.

W. H. Rodgers: The papers presented this morning, dealing with the interconnection of industrials and utilities have been very interesting and have dealt with a subject which promises to offer a very desirable and economical business alliance for both of the principals and the general public. The subject is particularly appropriate at this time when manufacturing economy is so highly desirable and power driven production machinery is becoming an increasingly important item in manufacturing expense. The opportunities for and the possibilities of such interconnections have as yet been but little recognized and the general subject deserves considerable emphasis so that it will be given due and sympathetic study and understanding by both industrials and utilities.

The economic details of the subject are of a rather confidential nature which the agents of both parties are naturally reluctant to discuss publicly and too specifically prior to the consideration of actual problems. Usually the problem of deciding the division of benefits is a complex one and one requiring a sincerely co-operative spirit. Each possible interconnection of this nature may be expected to be a new problem in itself and general deductions are wisely avoided. However those who see the general problem broadly are not at all reluctant to predict that such electrical power inter-connections will become very common and will yield at least as much of a saving as has resulted from inter-utility interconnections. Industrial Utility interconnections promise even greater returns on the invested capital.

From purely engineering or physical considerations, inter-connections between industrials and utilities may be expected to present no particularly difficult nor new problems either in apparatus or control equipment regardless of whether the interconnection be through rigid metallic conductors, static voltage transforming apparatus, or rotating machine equipment. The important considerations are usually those concerned with fulfilling the desired operating scheme and controlling the energy inter-change with as little investment and as economically as possible. In some cases the inter-connection will be desired to operate as an emergency power supply, in others as a peak load supply, in others as a base load supply, in others as a "dump" power supply, and in some it may be required to operate more flexibly to yield a combination of these functions.

The energy interchanged by so-called "fixed frequency ratio" ties, which include all metallic conductor ties, static voltage transformer ties and frequency converter ties of the synchronous-synchronous type, or the energy interchanged by so-called "variable frequency ratio" ties involving frequency converters of the ordianry induction machine type, having inherent variable "speed-load" characteristics but no load regulating equipment, can only be varied and controlled by manual or automatic adjustment of prime mover governors on one or both of the systems interconnected. Transformer phase regulating devices either in series with metallic conductors or in conjunction with ordinary voltage transformers and the frame rotating provisions often incorporated in ordinary "fixed ratio" converter sets are incapable of affording a means of regulating the division of energy or relative output of two interconnected systems although they do provide a means for adjusting the division of load carried by units of the same or similar type operating in parallel in the interconnection.

Direct or remote automatic adjustment of prime mover governors, so as to fulfill almost any desired interchange of energy, usually is not difficult with present day remote metering and regulating equipment. Apparatus is even available which provides the automatic selection of and adjustment of prime mover capacity in accordance with any predetermined economic combination of units operating in parallel.

Where it becomes desirable to provide adjustment or regulation of the energy interchanged at the point of interconnection, converters having an adjustable "speed-load" characteristic are required. Asynchronous-synchronous sets with load regulating machines in the rotor circuit of the wound rotor machine provide a means of manually or automatically varying the kilowatt load transferred through the set without requiring adjustment of prime mover governors. Such sets are usually built so as to provide variable load transfer in either direction. Two 20,000 KW. converters of this type have been operating successfully for the last three years near Lockport, N. Y. The adjustable load converters, although very flexible in performance, are somewhat more expensive, slightly less efficient, and inherently a little less reliable due to the auxiliary equipment than frequency concerters of the non-adjustable load type.

Irrespective of the equipment deemed desirable and selected for the purpose, American manufacturers are well prepared to fulfill in a creditable manner any of the needs for interconnection apparatus which have presented themselves up to this time.

M. R. McConnell: I think a very considerable amount has already been said on this subject. It seems to be just keeping you gentlemen from your lunch, to continue, but I will try to cover this very quickly.

Mr. Schnure has very ably presented the basic conditions under which interconnection operations are undertaken between industries and utilities, as well as pointing out the basic possibilities of inter-

change with iron and steel companies. I wish to emphasize plan 3 covered by Mr. Schnure, and mention an economy taken for granted. My comments are general in nature, and are not restricted to any one industry. First, to define my terms, I feel there is a considerable difference between "interconnection" and "interchange." "Interchange" implies a give-and-take principle of power flow, while "interconnection" does not necessarily do so, but merely means operation in parallel, and power may always flow in the same direction.

In the second and third plans, namely, where the industry supplies part of its power and obtains either the base or peak load from a utility, normally, the load carried by the utility is on a separate distribution system from that supplied by the industry's power plant. One of the basic reasons for parallel operation is to obtain the advantage of diversity between the two sources of power. This is more or less obvious, but due to various types of objections, very few industries run in parallel with the utility. To illustrate the saving possible, we recently started operating in parallel with an industrial concern. Previous to this, their generators supplied one bus in their plant and purchased power supplied the other. The units involved vary from 750 K.W. to 1500 K.W. in size, with the active total load in the order of 6000 K.W. It was necessary for the industry to stagger the motorized equipment on one or the other bus from day to day to get the best operating arrangement. By tying the two buses together electrically with the necessary protective equipment, an apparent reduction of more than ten per cent in the demand as a whole has resulted. This is a decided saving to the industrial plant. The difficulties of operating in parallel were easily and economically overcome. Industries both operating plants and purchasing power should keep this saving by parallel operation in mind.

Secondly, I would like to emphasize the desirability of taking base load power from the utility, and, if necessary carrying the peak on the industries' plant equipment. This applies when fuel must be purchased for power generation, even though process and other steam must be generated and may be generated by waste fuel. To illustrate, all power for an industry can be considered as being supplied from one power plant. When power is purchased, it merely takes the place of new units not installed. For economical operation in the power plant the new units would be operated as base load—the old ones to carry peaks. Consequently, as the purchased power is even more economical than the units, a base load should be carried and the peaks taken on the old equipment by burning a minimum amount of fuel.

This is theoretically sound. The investment has been made for the old units and their economy is relatively poor. The energy portion of an accurately designed rate represents the operating cost on efficient units, and is usually lower than the cost of operating and maintaining at high load factors the older units in the industries' plants. Also, it may be possible to maintain a very constant demand from day to day and month to month on the utility connection, making a yearly rate economical.

These general statements indicate that where mixed power supply is economical we should investigate carefully our operating costs before determining whether we shall buy peak or base load power.

Now, referring to the paper by Mr. Hoefle and Mr. Woodmancy: In this paper on "Absorption of By-Product Power" they have given us a constructive outline of how by-products can be used for power as well as illustrated what can be done by two progressive companies working on sound economic principles. I think it is of decided interest to notice how the Interlake Iron Corporation turned a dump power proposition into firm power by utilizing a further waste product, and that the operating arrangement between the two companies is apparently so excellent.

In the paper on "Interconnection between the Duquesne Light Company and the Davison Coke & Iron Company," Mr. Dignan and Mr. Kirk have described an operating example of interchange where the peak power is supplied by the utility and dump power taken whenever available. This would seem to be a very difficult operating arrangement which has been working out satisfactorily to both companies, illustrating that considerable is being done along these lines and pointing out that more can be accomplished if we will let our initiative guide us rather than sticking too close to conservative practice.

F. O. Schnure: Mr. Chairman and gentlemen, the only comment I have is to refer to that of Mr. Jones in which he intimated that the utilities would not be interested in interchange of power unless there was some profit to them in the interchange. Those of us who have watched the stock market during this depression, I think will agree that the stock of the utilities has held up better than that of the industrials; and I do not believe any utility need worry about that phase of the situation. It appears they are better salesmen and commercial men than we power men in the steel industry.

Now regarding the deferring of the load, I agree with him that this is rather an insidious paragraph, to put into the power contract: It is liable to create difficult situations. But still, if you get paid for doing something difficult, you are willing to do it. I think there is lots of load in a steel plant that can be deferred. Thank you.

M. H. Morgan: I am speaking in the absence of Mr. Abbiss who is unable to be here.

I believe that Mr. Cramer's comment on the speed of the M-G sets arising from Mr. West's comparison of high speed M-G sets with low speed engine driven generating equipment gave an erroneous impression. The sets in question are 500 r.p.m. which is actually not high except in comparison with the 90 r.p.m. engine driven units.

Mr. Baumgarten commented on the maintenance and repairs required for automatic M-G sets and sub-stations. In that connection I can only say that one repairman and his helper working day turn only take care of our five sub-stations including 7 M-G sets and two additional sets in the power house. The helper is also capable of taking care of this work and there are other men in the organization who can in an emergency do such work as has been required.

One other advantage of the automatic sub-station

is that it makes it possible for the power house operator to stop and start the M-G sets in the various parts of the plant as is required by the stopping and starting of the mills and other changes in plant operation. That, it seems to us, is quite an advantage and economy since he is always in touch with power conditions in the plant as well as on the 44 KV interconnecting transmission line mentioned by Mr. Cummins.

J. W. Bates: Mr. Cramer in his remarks made some mention of the fact that 25 cycles was no longer a very serious problem in deterring industries from making an interconnection with public utilities? That is probably generally true. However, the two largest industrial power systems, with the exception of the Aluminum Company of America, are both 25-cycle steel mill systems; the one in the Chicago district, connecting the South Works of the Illinois Steel Company and the Gary plants approximates a little more than 250,000 K.V.A. altogether and is getting up towards 300,000 K.V.A. in generating capacity; and the Carnegie-National Tube Company system in the Pittsburgh district which has about 150,000 K.V.A. of installed generating capacity. The problem of interconnection in both those systems would necessarily resolve itself into some method of frequency conversion. There have been several different schemes which have been mentioned as a means of accomplishing this interconnection. Each has certain advantages. Some of them are financial. On the other hand, it generally occurs in engineering problems that the ones that are nicest from an operating standpoint are the most expensive.

*Steam Turbine Lubrication**

By J. L. ROBERTS†

A steam turbine may be of two classes: a vertical turbine which has the main shaft in a vertical plane supporting the turbine rotor and revolving element of the generator on one bearing and with two or more guide bushings; or, a horizontal turbine which has the shaft of the turbine rotor and revolving element of the generator supported by three or more bearings lying in a horizontal plane. Since the latter class is the most commonly used, the remarks will be confined to this class. Fig. 1 is a photograph of a 35,000 KW General Electric Steam Turbine.

Design of Bearings

The bearings have three functions to perform, first to support the load of the rotating part, second to maintain alignment between the rotating and stationary blades; third, to provide means of introducing sufficient lubrication to keep the journal and bearing metals from coming into contact.

In performing the first function a bearing may be required to carry approximately 175 lbs. per sq. in. of projected area to support the journal. Therefore, the bearing must necessarily be of very strong construction and of the correct length to prevent end leakage which would affect the proper operation of the bearing.

The bearing must have a softer metal such as babbitt for a lining because there is less friction between dissimilar metals. Thus, in case of accidental contact at some time between the shaft and bearing, the shaft would usually escape serious damage, while the bearing can readily be rebabbitted.

In order to have the babbitt of a homogenous mass the babbitt is cast into the bearing by a centrifugal process which causes the impurities to rise toward the center of the bearing and in dimensioning the bearing to the correct size, these impurities are machined away.

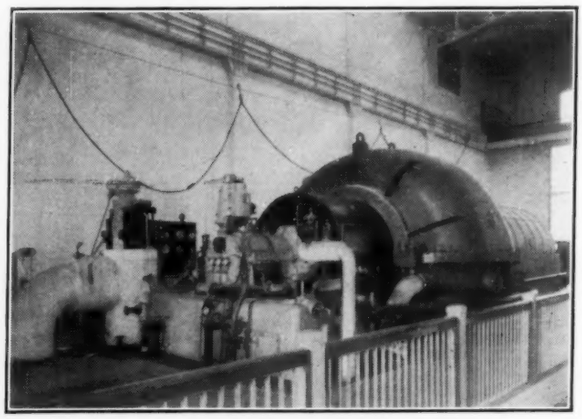


FIG. 1—35,000 KW. Steam Turbine Generator Set. The Puget Sound Power & Light Company.

To maintain alignment the clearance in a bearing must be kept small yet sufficient space provided to pass the required amount of oil for lubrication and cooling. The bearings of all late General Electric turbines are oiled cooled, that is, there is a sufficient flow of oil passed through the bearings to carry away all losses in the form of heat without undue rise of temperature and without the use of any water coils cast in the bearings.

Lubricating System

All the lubrication of a turbine is provided by a pressure feed system. The pumps are of the gear displacement type driven from the main shaft of the turbine through a reduction gear. An auxiliary pressure pump of the gear displacement type is used

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†Turbine Engineering Department, General Electric Company, Schenectady, N. Y.

to furnish lubrication for starting and stopping the turbine.

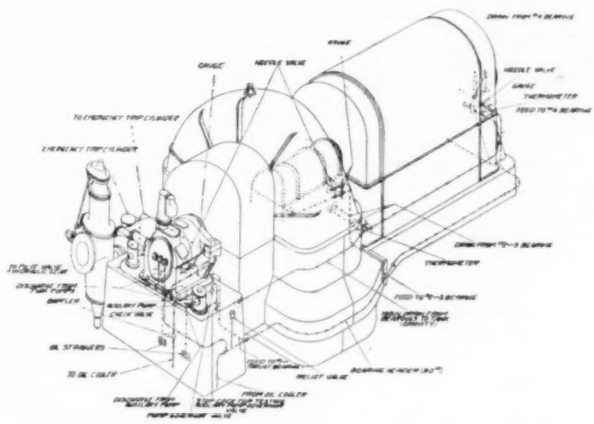

FIG. 2—Diagram of the Lubricating System on a 30,000 KW. Steam Turbine Set.

The oil is pumped from a reservoir, of such a capacity as to permit the amount of oil used for lubrication to circulate once in approximately eight minutes. This reservoir is placed at the lowest point in the feed system so that all the oil used may be drained back by gravity. The oil is at approximately 100-125 pound pressure as pumped. This high pressure oil is used to operate the controlling valve gearing, then is reduced to approximately 30 pound pressure by throttling for the bearing supply system. Before entering any of the bearings the oil is passed through an oil cooler so that the temperature may be controlled. The required amount of oil for each bearing is drawn off the systems of a calibrated orifice. The excess amount of oil pumped is drained back to the reservoir through a relief valve from the bearing supply system.

Fig. 2 is an isometric phantom made to illustrate the circulation system just described. Fig. 3 shows in detail, diagrammatically, the arrangement at the control end of the turbine shaft.

Lubrication

The main shaft bearings of the horizontal turbine are the most important points requiring lubrication, although the thrust bearing, reduction gears for the main oil pumps, valve mechanism and governor bearings should receive the proper care.

The lubrication problem is to supply the proper quantity of oil in such a form that it will maintain bearing surface separation under the high rubbing speeds, bearing loads and temperature. In some instances the journal speed is as high as 11500 feet per minute and the oil that actually lubricates a bearing is what adheres to the journal and forms a film to separate it from the babbitt. This is only a very small part of the total oil passing through the bearing. The remaining quantity of oil is used only to cool the journal as it passes over it and carry away the heat generated by the fluid friction of the oil.

The friction within the oil film varies inversely as its thickness, within certain limits, and approximately as the third power of the diameter of journal or at the rate at which it is sheared. Also the fluid

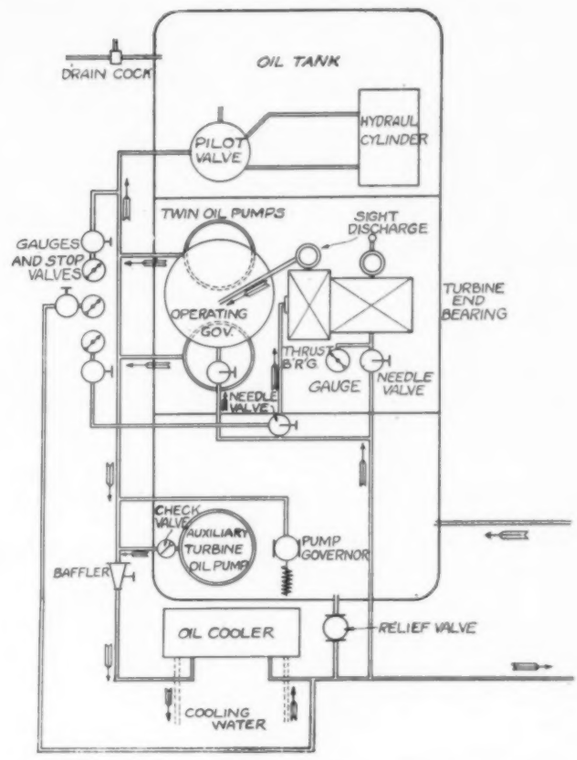

FIG. 3—Diagram of Lubricating System for Steam Turbines of 30,000 KW. and above.

friction within the oil film changes with its viscosity, (degree of fluidity) and the viscosity changes with the temperature of the oil. Therefore, the viscosity of an oil may be regarded as probably the most important characteristic of an oil for the proper lubrication of a bearing.

Oils

Lubricating oils are usually divided into three classes, Mineral, Animal and Vegetable, their sources being obvious. The latter two are unsuitable for turbine bearing lubrication, for when heated most of them lose their viscosity at a very rapid rate, and also from gummy deposits and mix permanently with water.

There is also likely to be a wide difference in the lubricating qualities of a mineral oil depending on the crude from which it is refined. It is desirable to have the viscosity-temperature curve as flat as possible.

The viscosity of an oil is a rough measure of the internal friction between the molecules of the oil and the viscosity decreases as the temperature increases, also the supporting power of an oil film decreases as its viscosity decreases. Therefore, it will be observed that it is desirable to have an oil that has a small change in viscosity due to its temperature in order that the viscosity may be as low as possible to minimize the internal friction and yet separate the journal and bearing. If it fails to do this, metallic contact will result in badly worn or injured bearings.

There are several other qualities desirable in a

turbine oil. It must be free from sludge forming ingredients and should separate readily from water. It must have all the surphur removed to prevent acid forming and attacking the highly polished journal surfaces.

Since the turbine oiling system loses no oil except due to neglected leaks and evaporation, and because it is used over and over again, only the best and most efficient oil should be used.

Care of Oil

To keep an oil in its best condition, several methods of purification are used in addition to the provisions made in the turbine reservoir for collecting water, dirt or sludge. Two systems are commonly used. With the By-pass system some of the oil is bled off while the machine is in operation; the by-passed oil is taken from the lowest point of the reservoir. Entering a settling chamber, the oil passes over a number of trays, where the water and heavier impurities are precipitated. Then the oil passes through a series of filter bags which remove finer impurities that remained in suppression. The purified oil is returned to the reservoirs.

Another method of purification with the By-pass system is a centrifugal oil separator. This utilizes centrifugal force to accelerate the settling out of suspended as well as precipitated impurities. The sediment is retained in pockets of the purifier while water is discharged from a spout and purified oil from another, which is returned to the reservoirs.

The By-pass system is usually of such a capacity as to circulate the entire quantity of oil in the reservoir once in 48 hours. This, however, is governed by the condition of the oil in the system.

With the Periodic Batch system the entire oil is removed from the reservoir when the turbine is shut down and permitted to stand and cool in a suitable tank so that water and other impurities may settle out, this usually requires about one week. Leaving the settling tank, the cold oil is passed through a series of filter bags to remove the finer impurities. In order to keep the turbine in service a new supply, or reclaimed oil is put in the reservoir. The entire oil is usually removed every 4 to 6 weeks, according to the condition of the oil.

Summary

For correct turbine lubrication, it is necessary to have an oil of such a quality and quantity that there will be no metal to metal contact between the journal and bearing. Faulty lubrication is evidenced by undue heating or rapidly worn bearings.

The oil must be capable of separating rapidly from water and have no sludge forming properties to clog the oiling system or impurities to injure the polished bearing surfaces. Furthermore, its physical properties should not change over its long periods of service.

Items of Interest

PERSONNEL CHANGES

L. A. Paddock, vice president of American Bridge Company, New York, since April, 1927, has been elected president to succeed the late Joshua A. Hatfield. Mr. Paddock, prior to 1927, had been president of Canadian Bridge Company, Ltd., Walkerville, Ont.

R. L. Leffler, formerly assistant superintendent of tool shops, Duquesne Works, Carnegie Steel Company, Duquesne, Pa., was appointed superintendent of blooming mills, roll shops and chipping. Other recent appointments at that plant follow: J. S. Tannehill, assistant superintendent in charge of rolling; D. A. Crowley, assistant superintendent in charge of chipping; K. H. McLaurin, master mechanic.

G. J. Bryen, master mechanic, and R. H. Shick, superintendent of rolling mills, retired July 1.

C. H. Butts, has been made vice president in charge of operations at both the Newton Falls, O., and Monroe, Mich., works of Newton Steel Company, Youngstown, O.

William J. Kibler was recently elected president of Buffalo Steel Company, Tonawanda, N. Y., to succeed the late J. G. Joseph.

Walter B. Enck, formerly vice president of Donner Steel Company, Inc., Buffalo, now a subsidiary of Republic Steel Corporation, Youngstown, O., has been appointed sales manager of Reliance Steel Products Company, Cleveland, manufacturer of open-hearth furnaces and water-cooled furnace equipment.

Leslie Allen, formerly manager of the Buffalo district, McClintic-Marshall Corporation, Bethlehem, Pa., has been appointed Pittsburgh district manager to succeed the late Thomas L. Cannon.

J. K. Bard has been appointed manager of works of the Buffalo district.

A. J. McCann of Otis Elevator Company, Pittsburgh, Pa., sailed on July 15th for Germany on his way to Kuznetzk, Siberia, to superintend the erection and starting of Blast Furnace Hoists. He expects to be gone about six months.

At a meeting of the executive committee of The International Nickel Company of Canada, Limited, held Monday, July 20, in New York, J. C. Nicholls of Copper Cliff was promoted from general manager to assistant to the president at Toronto, and Donald MacAskill of Copper Cliff was promoted from manager mining and smelting division to general manager. Dr. John F. Thompson, assistant to the president, was appointed vice president.

ASSOCIATION NOTES

Work is about completed on the Index of Proceedings of the A. I. & S. E. E. and Iron and Steel Engineer from 1907 to 1931. This Index is catalogued, as follows: 1st, Authors representing the leading engineers of the Iron and Steel Industry. 2nd, Subjects of papers which cover practically all engineering in the Iron and Steel Industry. The Index has been compiled for the purpose of providing for the engineers of the Iron and Steel Industry a ready reference and guide of electrical, mechanical, combustion, lubrication and safety practices for the past 24 years and totals over 3900 subjects. This Index will appear in the November issue of the Iron and Steel Engineer.